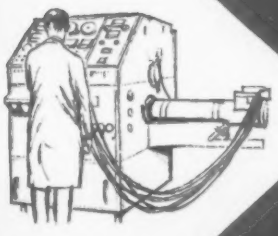
THE AEROPLANE

FIRESTREAK



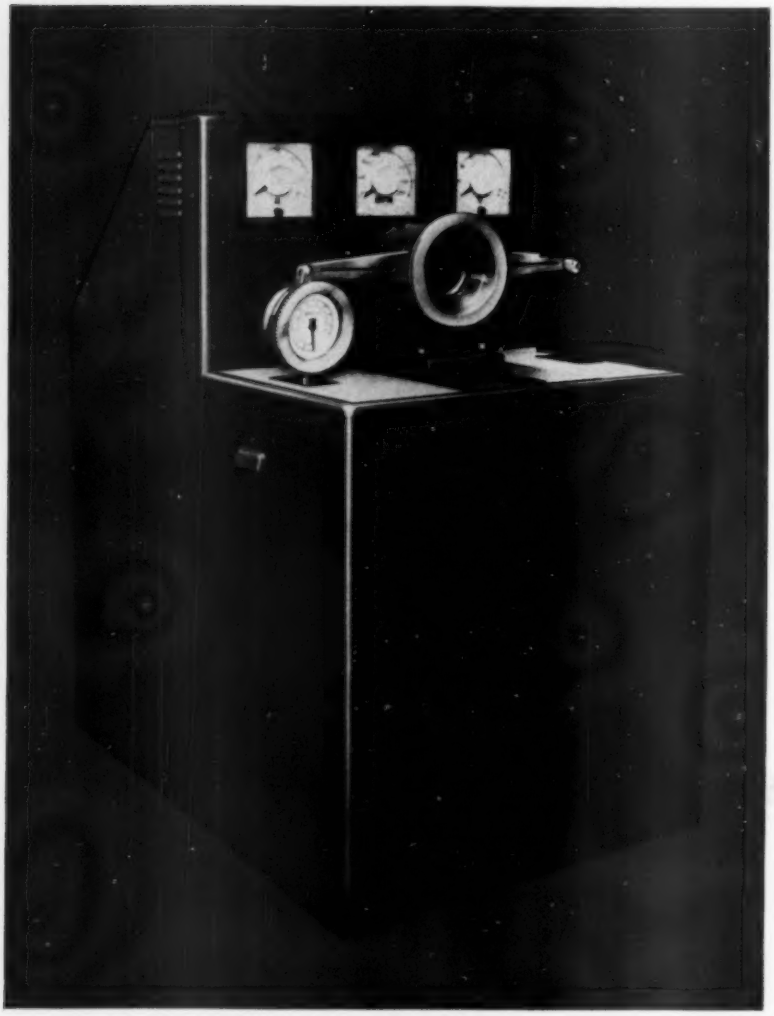
IN PRODUCTION FOR
THE ROYAL AIR FORCE AND THE ROYAL NAVY

DE HAVILLAND PROPELLERS LIMITED
HATFIELD • HERTS

NOW—PRECISION TESTING FOR YOU!

ROTAX TEST RIGS FOR ALL ELECTRIC MOTORS

VERSATILE DYNAMOMETER



Length	Height	Width
33·25″	58·50″	47·00″

• Motor load provided by a D.C. generator in conjunction with variable load banks • Instruments conveniently placed for constant observation • Motor torque measured by precision instrument • Controls easily accessible at front of panel • All steel cabinet with hammered-blue finish.

Now you can apply to *your* electric motors the advanced testing standards applied to the accessories of Britain's finest aircraft. For Rotax dynamometers are now available for general use.

The instrument shown gives precision test results on continuous and intermittent rated motors between 5 and 20 h.p., with speeds between 3,000 and 10,000 r.p.m. Motors of clockwise and anti-clockwise rotation can be accommodated.

BIG RANGE . . . COMPLETE SERVICE

One of our standard dynamometers is almost certain to suit your needs, but if you require a more specialised instrument our engineers will be glad to advise you.

For further information on Rotax Test Rigs, please write or telephone.

INDUSTRIAL GROUP

ROTAX

WILLESDEN JUNCTION, LONDON, N.W.10. (ELGar 7777)

LUCAS-ROTAX (AUSTRALIA) PTY., LTD. Melbourne and Sydney, Australia
LUCAS-ROTAX LTD. Toronto, Montreal and Vancouver, Canada

Every aircraft requirement in Piping and Ducting....

(including Ground Support Equipment)

....from a single **British** source

AVICA

Full information on any of the above products is available on request from:

Avica Equipment Limited

MARK ROAD · HEMEL HEMPSTEAD · HERTS · TEL: BOXMOOR 4711 · CABLES: AVICA HEMEL HEMPSTEAD

TA.1736
A

A natural evolution

Our research and practical work
on combustion systems for current and
projected air-breathing weapons
follows a line of development that stems
naturally from our experience
in aircraft gas turbine combustion.

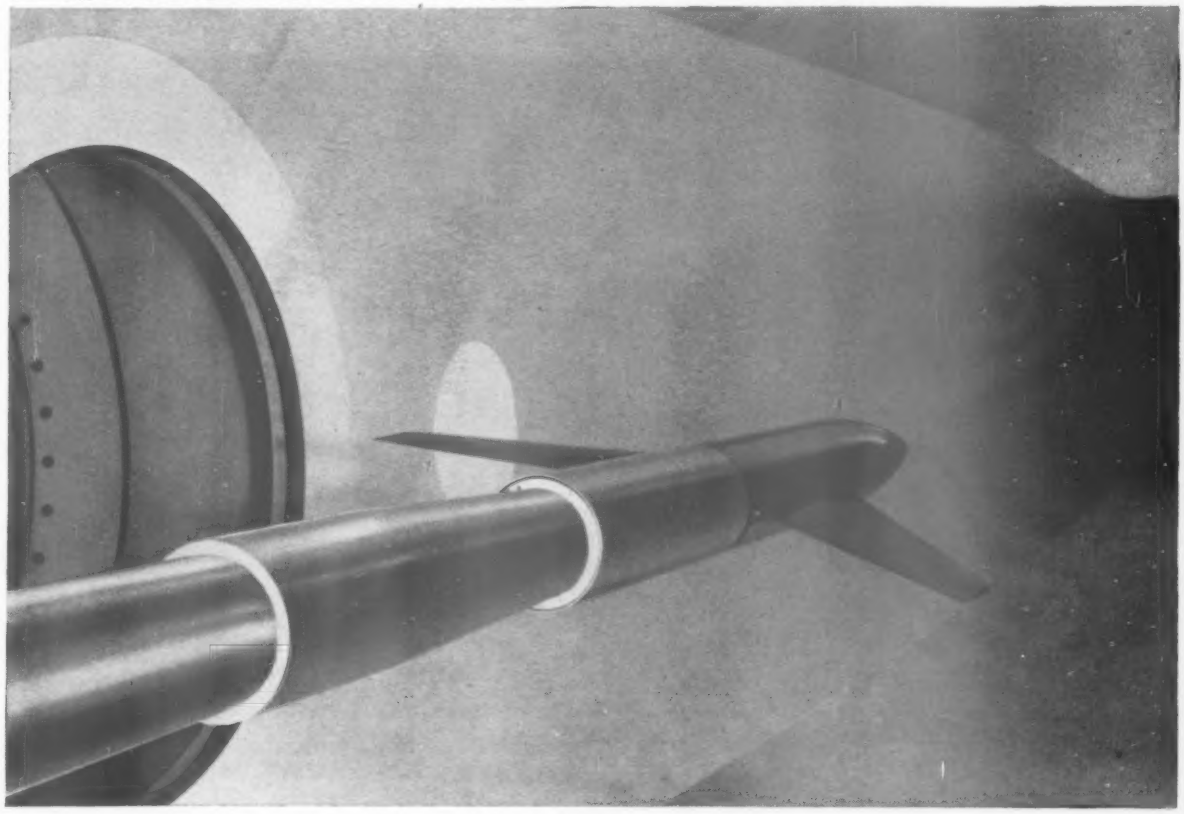
LUCAS

JOSEPH LUCAS (GAS TURBINE EQUIPMENT) LTD., Birmingham & Burnley.
LUCAS-ROTAX (AUSTRALIA) PTY, LTD., Melbourne & Sydney, Australia.
LUCAS-ROTAX LTD., Toronto, Montreal and Vancouver, Canada.

Araldite at Mach 2.8

Britain's newest, largest and most advanced wind tunnel is now in use at the Royal Aircraft Establishment, Bedford. It is employed for fundamental research and for tests on models of aircraft and missiles. The working section consists of two flexible top and bottom plates, 64 ft. 8 in. long and 8 ft. wide, supported between side walls 62 ft. 6 in. long and 8 ft. 6 in. high, forming a rigid structure weighing 400 tons. Both the flexible plates and the side walls of the tunnel are protected by 'Araldite' epoxy resins—yet another vitally important use for these tough, flexible coatings combining remarkable adhesive properties with outstanding resistance to corrosion.

Crown Copyright reserved: reproduced by permission of H.M. Stationery Office



May we send you full details of 'Araldite' epoxy resins for Industry?

Araldite epoxy resins

Araldite is a registered trade name

Araldite epoxy resins are used

- ★ **for casting high grade solid insulation**
- ★ **for impregnating, potting or sealing electrical windings and components**
- ★ **for producing glass fibre laminates**
- ★ **for making patterns, models, jigs and tools**
- ★ **as fillers for sheet metal work**
- ★ **as protective coatings for metal, wood and ceramic surfaces**
- ★ **for bonding metals, ceramics, etc.**

CIBA (A.R.L.) LIMITED

Duxford, Cambridge. Telephone: Sawston 2121.

AP 405

The **EXPERIENCE . . .**

. . . gained in supplying
Drop Forgings
in special creep-resisting
Alloy Steels
and nickel-based alloys
for gas turbines
since the first Whittle engine,
is at the disposal of
Designers and Metallurgists
in every industry.

A Main Supplier
of Drop Forgings
to those industries
with problems of
high stresses
and high temperatures ;
we are specialists in the
fields of

ASTRONAUTICS
and MISSILES

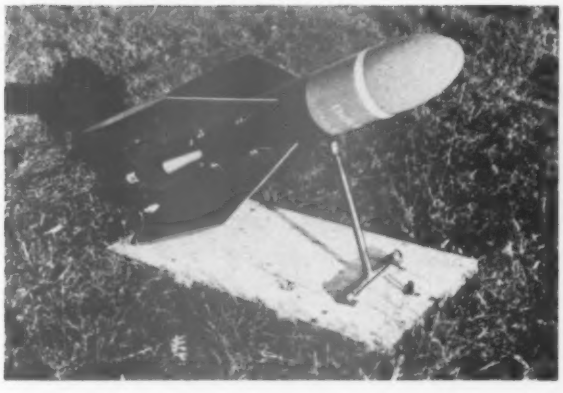
A 16mm Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

FIRTH-DERIHON
SHEFFIELD & DARLEY DALE

THE FIRTH-DERIHON STAMPINGS LTD. · SHEFFIELD · ENGLAND

SS 10

SS 11



the wire guided missiles manufactured in mass production by

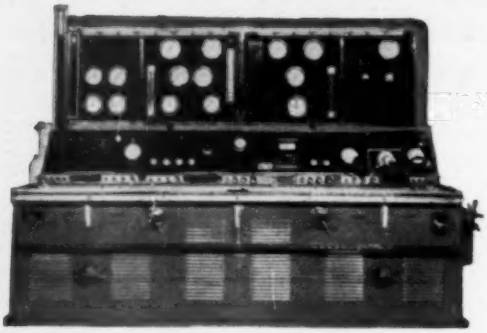
NORD AVIATION

2 À 18, RUE BÉRANGER
CHATILLON-SS-BAGNEUX
SEINE
TÉLÉPH. ALÉSIA 57-40

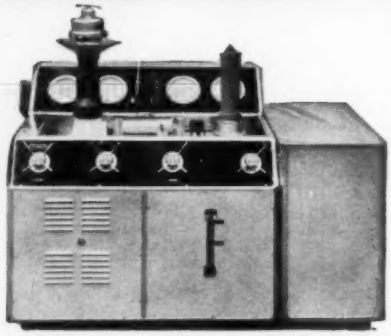
HML

FOR HYDRAULIC TEST EQUIPMENT

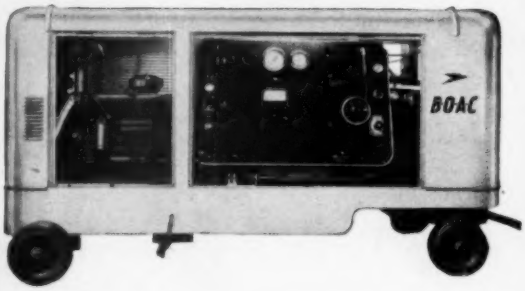
The name HML has established itself firmly in the field of Hydraulic Test Equipment. Major contracts, for servicing both civil and military aircraft, are in hand and continuous and increasing interest is being shown in HML equipment. If you have a problem in hydraulic testing, why not call us in for consultation.



The HML Universal Hydrostatic Test Rig MK. XI provides bench testing for all hydraulic components and aircraft pumps.



The HML Universal Propeller Component and Hub Test Bench. Designed to deal with propeller valve and hub assemblies, is universal in pressure and flow range and can be pre-set to test various propeller components.



The HML Mobile Universal Hydraulic Test Rig gives operational testing on the aircraft when it is being serviced for flight.

THE HML UNIVERSAL PUMP TEST RIG Designed to test hydraulic pumps with input torques up to 148 lbs. ft. from 0–2500 r.p.m. and 148—67 lbs. ft. from 2500–5500 r.p.m. in either direction, *i.e.*, 0–70 h.p. between 0–2500 r.p.m.. 70 h.p. from 2500–5500 r.p.m.

HML EQUIPMENT INCLUDES:

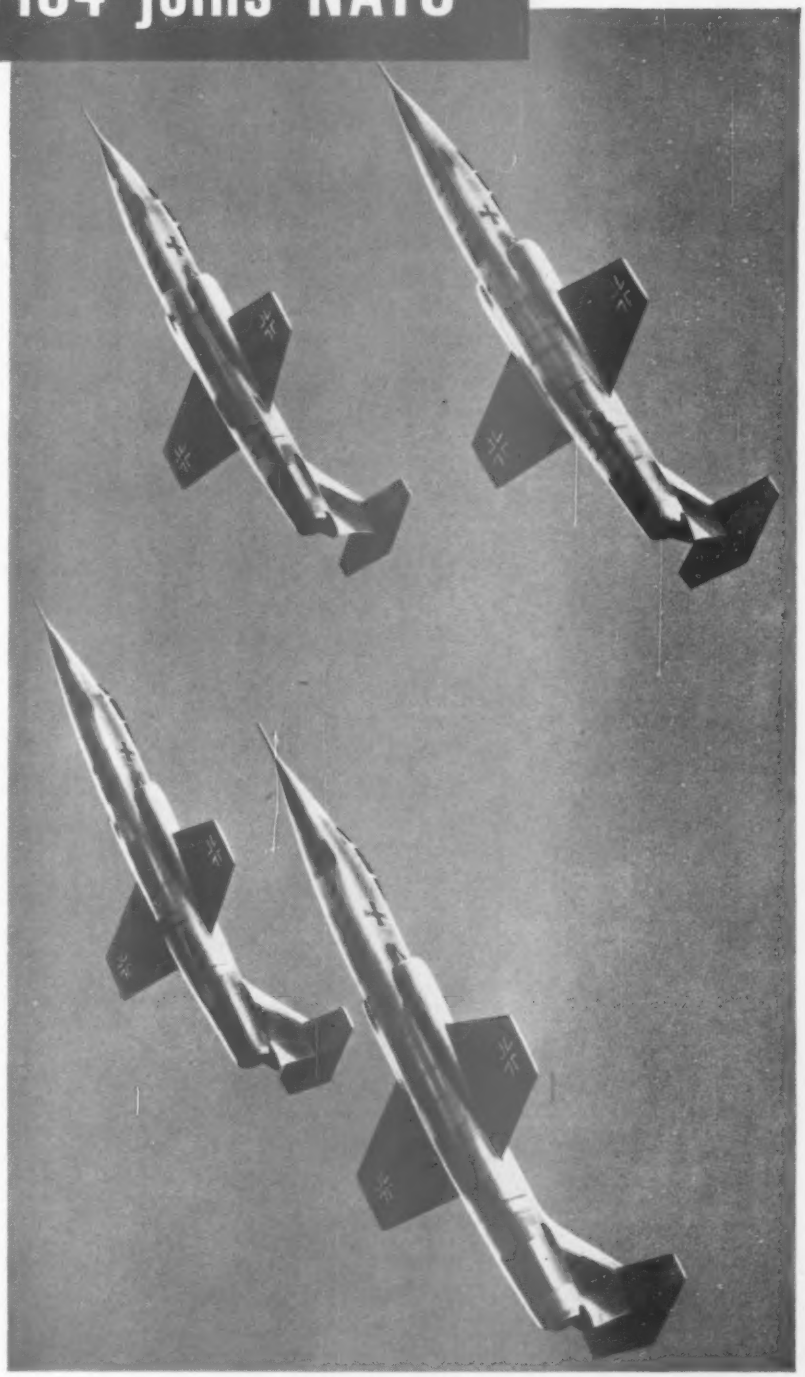
Universal Hydraulic Test Rigs MK. II and MK. III (Diesel or Electric Powered)
Hydrostatic Rig (Single and Double Acting)
Aircraft Pump and Hydraulic Motor Test Rig
Autostatic Hydraulic Power Pack
Brake Test Unit
Pulsometer Pump Test Unit
Tensioning Test Unit
High-speed Gear Boxes
High-pressure Filters
High-pressure Accumulators
Valves
Universal Hydraulic Tyre Remover
Hydraulic Propeller Test Bench

HML

HML (ENGINEERING) LTD. AIRCRAFT DIVISION
466-490 EDGWARE ROAD, LONDON, W.2. Telephone: PADdington 0022

OHB/7470

Lockheed's F-104 joins NATO



After a two-year evaluation period during which West German Defense Ministry experts investigated and flight tested airplanes made by 12 competing manufacturers, the plane selected for purchase and manufacture under license in West Germany is Lockheed's famous "missile with a man in it" – the *F-104 Starfighter*.

Never before has a single airplane done so many things so well as the present U. S. Air Force version: Interception, Air Superiority, Ground Support and Reconnaissance – and with so low *proven* maintenance and operating costs.

Holder of the world speed, altitude, and seven time-to-climb records, the current F-104 will be still further developed to meet the specific needs of West Germany and other allies requiring a multi-purpose fighter instead of several separate aircraft for specialized needs. To its already amazing performance is being added all-weather capability for fighter bomber and interceptor missions and also an advanced reconnaissance capability.

The licensing of German manufacturers to produce this advanced version will make it available to West European nations at relatively low cost.

LOCKHEED

JET TRANSPORTS · JET FIGHTERS · JET TRAINERS · COMMERCIAL & MILITARY PROP-JET TRANSPORTS · ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT · WEAPONS SYSTEMS MANAGEMENT · ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT · ADVANCED ELECTRONICS · AIRBORNE EARLY-WARNING AIRCRAFT · AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT · GROUND SUPPORT EQUIPMENT · WORLD-WIDE AIRCRAFT MAINTENANCE

Precision Fabrication work in Heat-resisting steel for Guided Missiles and related equipment

B.A.P. have development and production facilities for Guided Missile work, and offer manufacturers in the industry a first class fabrication service in heat-resisting steels for components and ancillary equipment

• • •

A.I.D. and A.R.B. approved

BURNLEY AIRCRAFT PRODUCTS LTD

FULLEDGE WORKS · BURNLEY · LANCS · ENGLAND

Telephone: 3121/2 and 3203 Burnley (3 lines) Grams: 'AIRCRAFT' Burnley

REPAIR DIVISION: Britannia Works, Queensgate, Burnley. Telephone: 4102

INDUSTRIAL FABRICATION DIVISION: Grosvenor St., Stoneyholme, Burnley. Telephone: 3184

Associated with RENFREW AIRCRAFT & ENGINEERING CO. LTD. RENFREW, ONTARIO, CANADA

STATE EXPRESS
555

The Best Cigarettes in the World

The House of STATE EXPRESS. 210 PICCADILLY. LONDON. W.1.

ELLIOTT

Leaders in the design, development and manufacture of lightweight radar equipment and navigational aids for aircraft installations where space, weight and power requirements are of primary importance.

– 21 SERIES –

VHF communications and VOR/ILS equipment

compact—lightweight—low power consumption

New design features, including the use of transistors and printed circuits resulting in an overall reduction in size and weight, save at least 40 lb. per aircraft. With a total weight of only 57 lb., this installation is the lightest, most compact equipment of its type in production today.
A brilliant performance of 560 channels with 50 kilocycle spacing and the fact that down draught cooling is unnecessary, make this installation invaluable to modern airline operators and aircraft manufacturers.

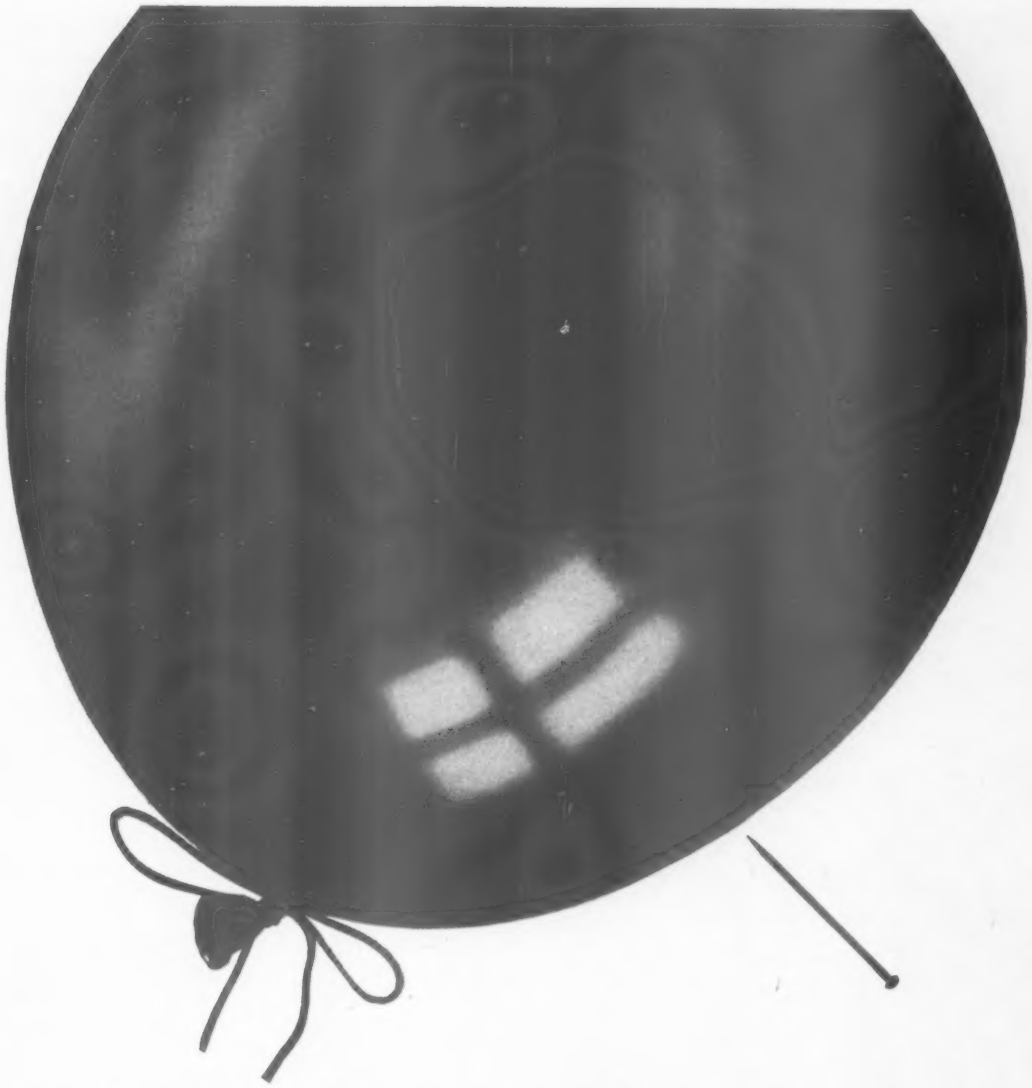
* *Made by Elliott Brothers (London) Ltd. under licence from the Bendix Aviation Corporation, U.S.A. All parts interchangeable with Bendix American manufactured Equipment*

Enquiries to:

ELLIOTT BROTHERS (LONDON) LTD

RADAR DIVISION

Elstree Way, Borehamwood, Herts. Telephone: Elstree 2040 *A Member of the Elliott-Automation Group*



Explosions are such noisy things

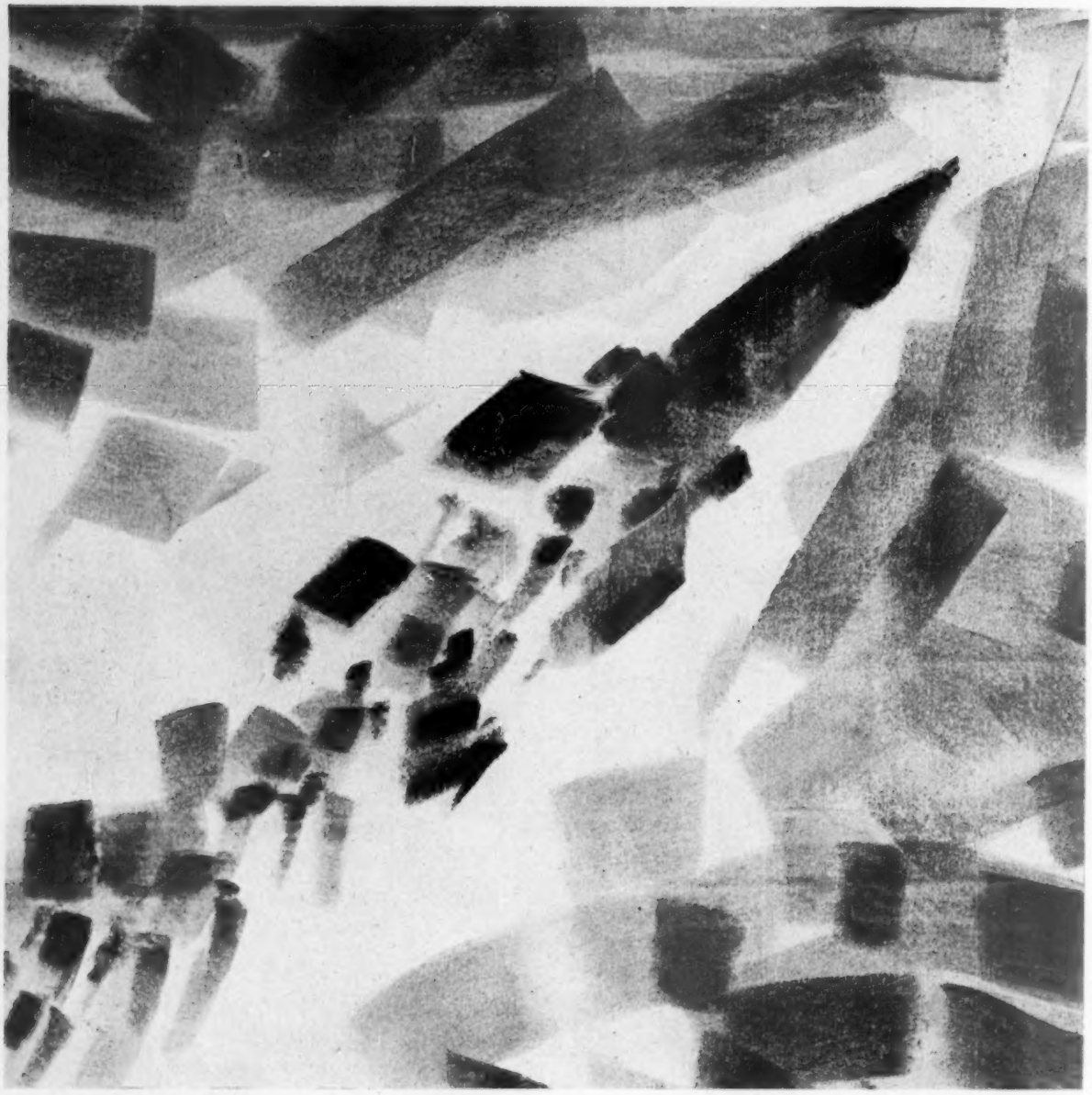
There are, of course, several systems for preventing explosions in fuel tanks struck by missile fragments. But most of them are complicated—and they can only be used once. So they're not very practical for very high-speed aircraft, where aerodynamic heating of the tank walls can produce explosive conditions many times in one sortie.

Now B.O.A.E. have developed a new system for discouraging explosions. It consists of a simple converter containing liquid nitrogen. Nitrogen vapour is introduced into the tank pressurisation line . . . and keeps the atmosphere in the tank inert from take-off to touch down. For aircraft of 3,000 gallons fuel tankage, the whole system weighs less than 50 lb. It's all very simple. No electrical circuits. No detection units. No explosions. Can't think why someone hasn't thought of it before.

British Oxygen Aro Equipment

THE PINNACLES · HARLOW · ESSEX

British Oxygen Aro Equipment combines the resources of the British Oxygen group of companies and the Aro Equipment Corporation of Ohio



THE SEEKER

One of a series of drawings by Colin Munro

Teddington Aircraft Controls have applied the experience gained in the design and development of automatic control equipment for manned aircraft to the requirements of the missile age.
This equipment includes: ✱ Temperature Controls ✱ High Temperature Valves
Pressure Switches ✱ Time Switches ✱ Fuel Pressurisation Equipment
Vent Valves ✱ Pressure Regulators

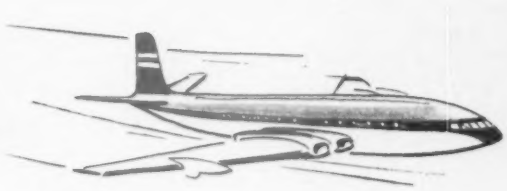
Teddington CONTROLS

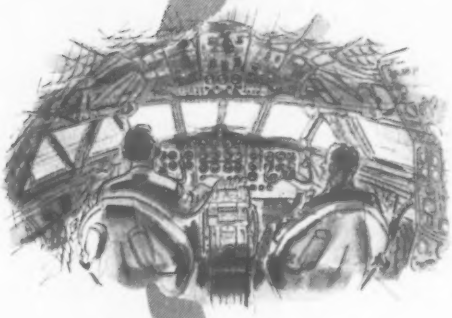
REGD. TRADE MARK

TEDDINGTON AIRCRAFT CONTROLS LTD • MERTHYR TYDFIL • SOUTH WALES • Tel: Merthyr Tydfil 666
London Office: COLNBROOK BY-PASS • WEST DRAYTON • MIDDLESEX. Telephone: Colnbrook 2202/3/4

TAC194

Bauduin





Preparing air traffic control for the Jet age:

Automatic flight progress display

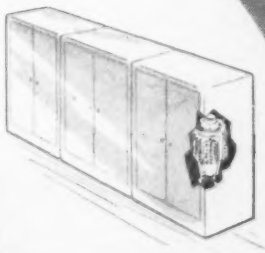
SATCO

Automatic Air Traffic Control System

SATCO increases the handling capacity of air traffic control centres without any sacrifice of safety and without requiring any major change in present flying procedures or air traffic organisation.

Principal features of SATCO:

Automatic coordination between control positions
Automatic flight data display systems
Extensive facilities for civil/military coordination
Special calculations for turbine aircraft
Special pre-departure facilities for air line operators
Uses latest type digital computers, fully transistorised
Fail-safe and self-checking.

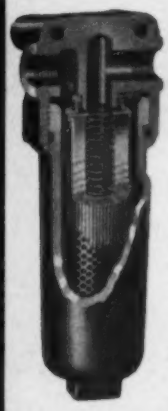


Computer and memory drum - calculations and conflict search

Flight planning

SIGNAAL

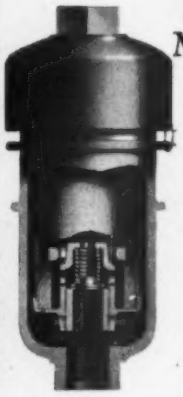
N. V. HOLLANDSE SIGNAALAPPARATEN HENGELO - NETHERLANDS



On the right is shown part of the pleated paper 'Micronic' element

PUROLATOR
'Micronic' filters

can be supplied for all aircraft applications. Filtration —from 5 microns upwards— can be provided according to requirements. A standard range of high and low pressure models is available and new designs can be prepared when necessary.



PUROLATOR
Metal-edge filters

These metal filters provide edge filtration so that solid particles cannot become jammed in the spaces. Maintenance is thus made easy. The element is of robust construction and can resist high differential pressures. Spacings ranging from ·001" to ·020" can be supplied with either high or low pressure casings.

To the left of the filter is shown a portion of the metal-edge filter element, unwound to show construction

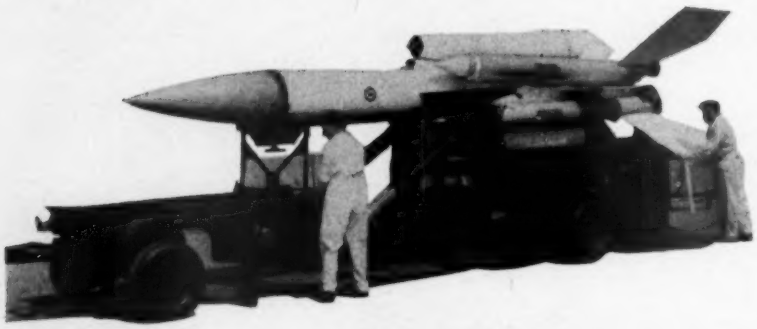
PUROLATOR FILTERS

Regd. Trade Marks: Purolator, Micronic

AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

A CATALOGUE OF PUROLATOR 'MICRONIC' AND METAL-EDGE FILTERS WILL BE SENT UPON REQUEST

M.L. AVIATION CO. LTD.



Designers and manufacturers of the ground handling equipment for the

BRISTOL "BLOODHOUND"

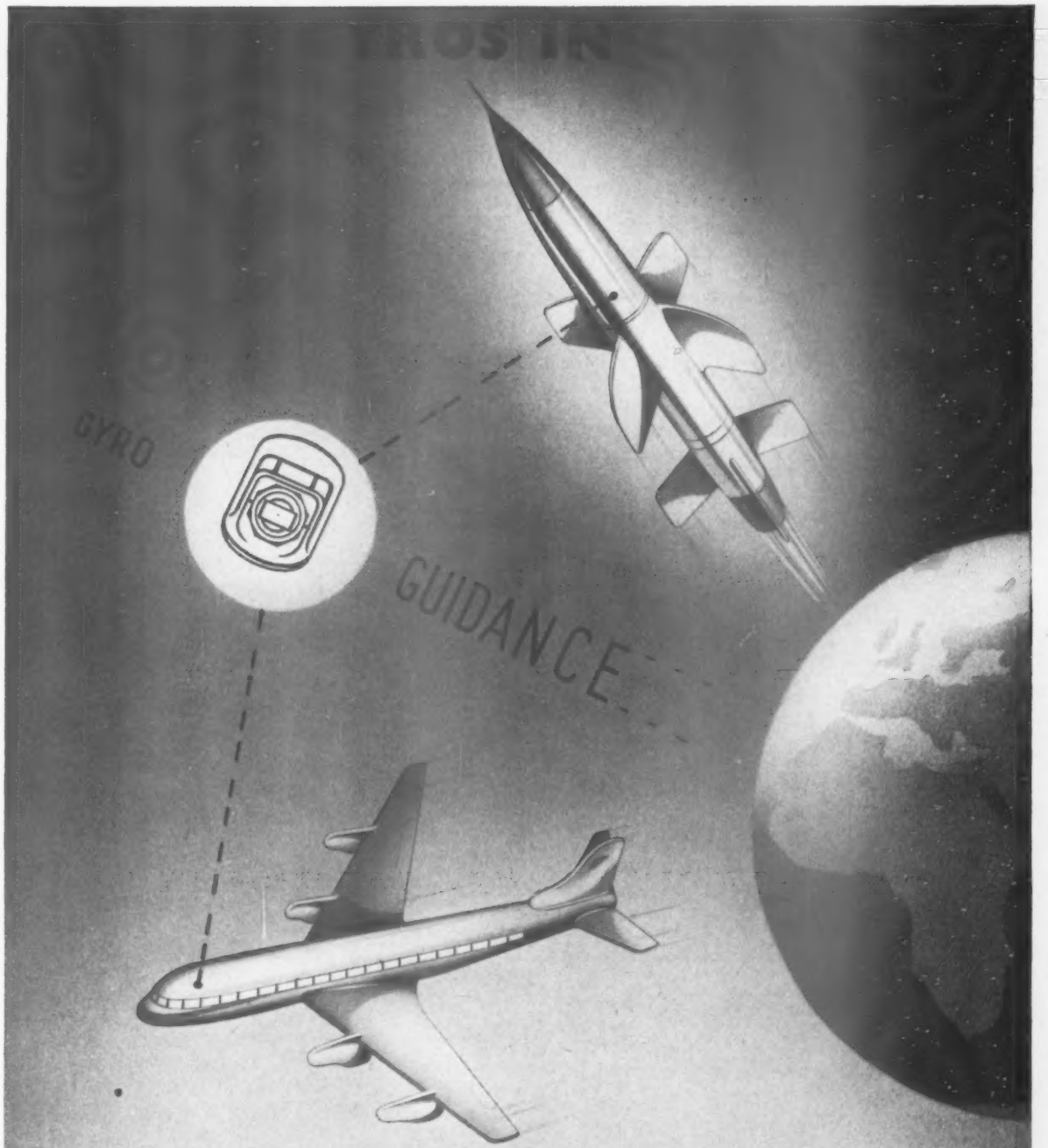
and

DE HAVILLAND "FIRESTREAK"

We are also manufacturers and designers of missile cooling units—cooling trolleys specially designed to prevent overheating of missile equipment prior to launching.

M.L. AVIATION COMPANY

THE M.L. AVIATION CO. LTD.
WHITE WALTHAM AERODROME, MAIDENHEAD, BERKS
Tel.: Littlewick Green 248. Grams: 'EMELAIR' White Waltham



REID & SIGRIST LTD.

BRAUNSTONE WORKS · LEICESTER

Telephone 858101 (5 lines)

SPECIALISTS IN GUIDED MISSILE AND AIRCRAFT INSTRUMENTATION

Your enquiries are invited for any of our products in the Gyro field. We have participated in many important research and development phases of guided missile control and production of precision instruments.

Contractors to: Admiralty, Ministry of Supply and Foreign Governments. A.R.B. & A.I.D. Approved

"WE HAVE UNDER DEVELOPMENT AN ANTI-TANK GUIDED WEAPON WHICH WILL + IF ALL GOES WELL + REMOVE THE HEAVY TANK FROM THE BATTLEFIELD" +

(Secretary of State for War in the House of Commons)

This guided weapon is being developed and built by the

FAIREY

Weapon Division

FAIREY AVIATION LIMITED (WEAPON DIVISION) · HAYES · MIDDLESEX
(A member of The Fairey Group of Companies)

THE AEROPLANE

Incorporating
Aeronautical Engineering
Edited by - - THURSTAN JAMES

© Temple Press Limited, 1959

Founder and First Editor:
(1911-1939), C. G. GREY

The proprietors will consider any written requests to reproduce articles and illustrations appearing in this journal. Comment and brief extracts which acknowledge *The Aeroplane* are permissible.

Proprietors:
TEMPLE PRESS LIMITED
Chairman and
Managing Director:
ROLAND E. DANGERFIELD

Head Office:
BOWLING GREEN LANE,
LONDON, E.C.1.
Telephone: Terminus 3636
Telegrams:
"Pressimus London Telex"
Telex: 23839

Vol. 96. No. 2485 APRIL 17, 1959

Annual Subscription Rate: U.K. £4.15.0.
Overseas £5. Canada and U.S.A. $15.00

AN UNSUPPORTED ASSET

MOST of the space in this issue of THE AEROPLANE has been devoted to consideration of guided missiles and vehicles for the exploration of space. During the course of the week in which it went to press the Students and Graduates section of the Royal Aeronautical Society was honoured by a visit from Mr. Donald Douglas, Jnr. Bearer of an internationally known and honoured name, Mr. Donald Douglas is now president of the vast organization which his famous father founded. In talking to the younger generation of R.Ae.S. members Mr. Douglas told them many interesting things about the U.S. aircraft industry. One of his most significant statements was that 85% of the business done by the U.S. aircraft industry was with the U.S. government. When we consider the volume of business done by the Douglas concern in the civil market one begins to see exactly what that statement means.

This week the Southampton section of the Institute of Production Engineers have been holding their annual conference at Southampton University. The theme of the conference is the "Aircraft Industry—A National Asset." In accord with tradition the proceedings open with the Sempill lecture, the author of which this year is Lord Douglas of Kirtleside, and as chairman of British European Airways his views must carry much weight.

Lord Douglas is in no doubt about the value of the industry to the nation and indeed when one considers how closely B.E.A. has worked with the industry in the development of such an internationally famous aeroplane as the Viscount it could be said that B.E.A. might be regarded as its second strongest supporter.

Let us revert to that most remarkable figure of 85% set on the record by Mr. Douglas. In this country the proportion in the past must have been of the same order, if not higher. Since the publication of the "black" white paper of 1957 government orders to the British aircraft industry have been heavily cut.

We should much like to see a plot of defence expenditure set out on a most interesting chart given by Lord Douglas which shows the upward surge of exports. We should be very much surprised if such a conjunction of data did not disclose how closely our aircraft exports are linked to defence spending. The inevitable corollary is that the sudden fall in defence expenditure arising from this country's acceptance of the American rocket Thor (incidentally made by Douglas) must inevitably be followed by a similar catastrophic decline in exports.

In our view perpetual harping on the wonderful steady climb of British aircraft exports is most harmful at this stage unless at the same time every effort is made to show how this climb is linked to government expenditure on defence in the past; in other words, we are now harvesting the crop sowed five years ago and more.

We suppose that most of the readers of this page know enough about the business of aeronautics to need no wordy explanation of how this comes about. Let us wrap the whole thing up in a nutshell by setting out one of the reasons why military aeroplanes cost so much money (to quote Mr. D. Douglas, Jnr.), ". . . the spiralling cost of new weapons is a result of the far greater emphasis now placed on research and development and on new complex equipment." Also to be noted is a particularly relevant disclosure by Mr. Douglas, Jnr., ". . . the (U.S.) government is relying more and more on privately owned facilities for defence work and the (U.S.) industry has been forced to invest in new plant and research, test and production facilities as never before. . . ."

What price effective competition in the international aircraft market when the British industry is blessed with a Government that has decided to drop manned aircraft and go over to guided missiles? Let there be no mistake, if money is not forthcoming for research and development, then British aeroplanes able to make their mark in the international market will not be forthcoming either.

Last week the Colston Research Society of Bristol University also staged a symposium. This was a gathering of scientists who met to discuss the problems of flight at Mach=20, or travelling at 18,000 ft./sec. 180,000 ft. above the earth. This is no dream, but a practicable development. Speakers at the symposium disclosed a fascinating possibility of sending transport gliders at fantastic speeds halfway round the world or further—without any engines at all, once the launching boosters had finished firing.

While these learned and eminent men continue with their experiments and analyses, let us endeavour to remind those who govern this land that our Ministry of Supply is still dithering about whether to build a supersonic transport which shall travel at Mach=1.8 or as slowly as Mach=1.2. And if the awful gap which exists between this and hypersonics is not sufficiently horrifying, we had better remind everyone that this coming summer in London world scientists are to discuss space flights. What contribution will the British aircraft industry be able to make in this new field?

C

Matters of Moment

Gnome-engined Feeder-liner?

FOR some considerable time now the de Havilland company has been closely studying the market for a small feeder-liner which could be classed broadly as a Heron/DC-3 replacement. Covered by the type designation D.H.123, it is in the active project stage, although no decision has yet been taken on its possible construction. Two de Havilland Gnome turbo-props might well provide the power.

An aeroplane of this kind should have good market prospects, and although neither of the British Corporations could be expected to sponsor its development, B.E.A. would probably be interested in buying a few "off the shelf" to replace its D.H.89s and DC-3s in 1960-61. In view of the past successes of British feeder-liners, an aeroplane of the D.H.123 type might well qualify for Government sponsorship, along the lines suggested by Lord Douglas in his Institution of Production Engineers' paper yesterday (see next page), with a U.K. airline—Corporation or independent—being given financial assistance to undertake the rôle of first operator.

Hypersonic Practicabilities

UNDER the auspices of the Colston Research Society a symposium on Hypersonic Flow was organized in the University of Bristol on April 6, 7 and 8. The director was Professor A. R. Collar, the secretary Dr. J. Black and the recorder Dr. J. Tinkler, all of the department of Aeronautical Engineering of the University. There were fifteen distinguished speakers. In addition Professor A. C. B. Lovell, professor of radio astronomy at Manchester University, was the guest speaker on April 7. The proceedings of the Symposium will be published by Butterworths in the "Colston Papers."

Unfortunately we have inadequate space to report the occasion. However, when so much is being said and written about supersonic aircraft it seems important that our readers should be told something of papers which discuss the practicability of hypersonic flight, that is the controlled flight of manned vehicles, able to alight on the Earth's surface after flying at Mach=20 at heights of 180,000 ft. In this connection we found the paper by Dr. A. J. Eggers of NASA, chief of the 10 x 14-in supersonic wind-tunnel branch at Ames Research Centre, Moffett Field, of special interest.

Photograph copyright "The Aeroplane"

SHOWING THE FLAG.—Three Vulcans of Bomber Command have been participating in the World Congress of Flight at Las Vegas. This British team was led by Air Vice-Marshal G. A. Walker, the A.O.C. of No. 1 Group, seen here (second left) with members of the team prior to departure.

His account of theoretical analysis and experimental verification in the field of hypersonic flight is fascinating. The paper runs to nearly 7,000 words and contains 24 illustrations. We have selected perhaps a third of it in the author's own words in the hope that the presentation of even this truncated version will induce a wide public to take an interest in this fascinating subject where, in an Alice-in-Wonderland world of flight at speeds twenty times that of sound, lift is obtained from flat-topped conical fuselages and flat-topped, convex under-surfaced wings. These extracts appear on pp. 483-4.

If ever there was doubt about the need for a vigorous, well-planned national programme of aeronautical/astronautical research, the papers of the Colston Symposium should resolve all doubts. In this context discussion of the practicability of building a 1.2 supersonic transport has a positively olde worlde flavour.

Mr. Donald Douglas in London

HIGH costs of new U.S. aircraft and missiles were emphasized by Mr. Donald W. Douglas, Jnr., president of the Douglas Aircraft Co., Inc., when he spoke to the Graduates and Students Section of the Royal Aeronautical Society on April 8.

About 85% of the U.S. aircraft industry business, he said, is for the U.S. Government—it being understood that products of the industry include missiles, their powerplants, and vehicles

WEIGHT-LIFTER.—The new Sikorsky S-60 flying crane at Stratford, Conn. With two 2,100-h.p. Pratt & Whitney R-2800 engines it carries a 4-6 ton payload over 100 miles.

designed for outer-space exploration besides conventional aircraft. The spiralling cost of new weapons is a result of the far greater emphasis now placed on research and development and on new complex equipment.

A total investment of some $10,000 million may be involved before a new weapons system reaches operational readiness.

As the cost rises the number of vehicles obtainable for a fixed expenditure rate declines. The total cost for the financial year 1960 is estimated at £2,333 million. It provides for only 1,610 aircraft for the three Services.

There are no signs, said Mr. Douglas, of a change in this trend, and in fact as the Space Age is entered the probability is that costs will continue to rise and that fewer weapons will be produced. Because of expenditure limitations the U.S. Government is relying more and more on privately owned facilities for defence work and the industry has been forced to invest in new plant and research, test and production facilities as never before. More than $2,000 million has been spent by the industry since the Second World War to meet this demand, and within the next five years another $1,000 million or more may have to be invested.

The industry's financial problems are increasing to major proportions and the new weapons systems have had a profound effect on the industry. One manufacturer recently spent $600,000 on an unsuccessful bid.

More than 80% of the missile business in the U.S.A. is in the hands of the aircraft industry. With this evolution have come many changes in names, organizations and financing. The aerodynamicist no longer dominates; numbers of physicists, mathematicians, metallurgists, chemists, electronics engineers and nuclear scientists are still increasing.

At present some 760,000 people are employed in the industry, making it the largest single manufacturing employer in the States. In 1939 American aviation employed 63,000 people and produced 5,800 aircraft, one-third of which were military. The industry reached its peak employment of 1,300,000 in 1943, and peak aircraft production reached 95,200 the next year.

The rapid post-War decline resulted in the employment of 237,300 people in 1946, and 36,000 aircraft were produced, only 4% of them military. In 1957 there were 878,000 employees; of the 12,000 aircraft built 5,500 were military.

Out and Back

ONE of the major problems in the ballistic missiles business to which a great deal of time and money has been devoted is the rather basic one of ensuring that what is cast out beyond the atmosphere surrounding the Earth will come back into it unscathed by the experience. "Re-entry" has come to be the most commonly used of all the terms that are employed both inside and outside the confines of ballistic missile technology; and now that the prospects of manned vehicles making the same passage to and from space are coming closer to fulfilment, the re-entry problem is becoming even more acute. Authoritative discussions on these matters will be found starting on page 455.

Last week some encouraging news of progress in this general direction came with the announcement from America of the successful recovery of an experimental ICBM nose cone. This, it was said, was the first occasion on which a nose cone had been sent over the full intercontinental range of 5,000 miles and recovered.

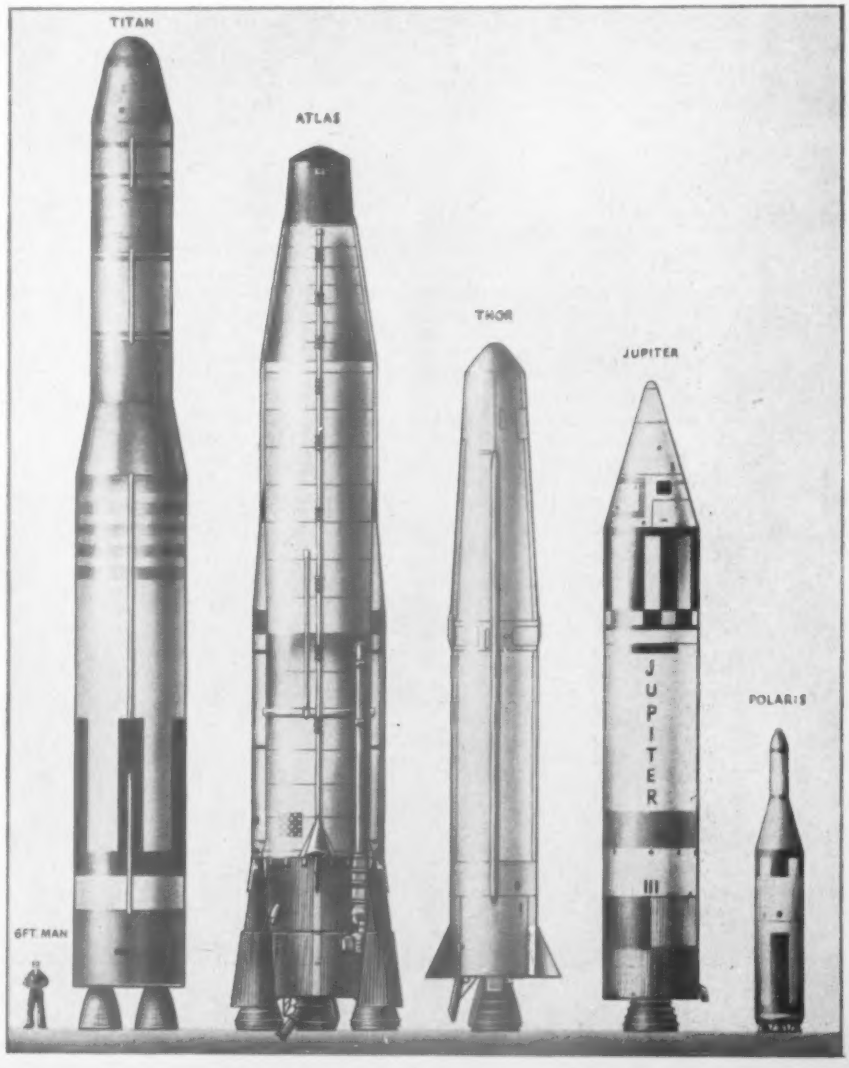
The vehicle was a Thor-Able research rocket and the impact area was in the neighbourhood of the Ascension Islands. A report from Washington gives the official view that this successful recovery of the nose cone could be regarded as an additional bonus to the test programme in providing physical verification of the telemetred data.

The U.K. Transport Aircraft Policy

THE importance of the aircraft industry as a national asset, and the consequences of declining Government-sponsorship, were stressed by Lord Douglas, chairman of B.E.A., in a paper given before the Institution of Production Engineers' Aircraft Production Conference in Southampton yesterday (April 16). The paper was entitled "The Aircraft Industry—A National Asset; The Operator's Point of View."

If Government sponsorship is reduced in proportion to the declining defence interest in manned aircraft, the rate of aeronautical progress for civil as well as military purposes will slow down, and unless this slowing down occurs in all countries at once, those countries which economize in this way will soon find themselves squeezed out of the aircraft business altogether. Lord Douglas enumerated nine reasons why the British aircraft industry is particularly worth fostering despite the changing defence requirements.

Among the lessons to be learnt, according to Lord Douglas, are these: our manufacturing resources should be concentrated on a narrower front in the civil field; greater effort must be directed towards more rapid and more thorough pre-service development; only one major transport design should be undertaken at a time by any one company; every new transport should be developed in close association with a U.K. airline, which should be the first operator of the type; Government support is needed for certain important transport types which have good export possibilities but do not meet either Corporation's major requirements; for the next decade we should concentrate on "bread-and-butter" types—the subsonic trunk-route jet and the second-line turboprop, low-fare and freighter types; development of longer-term projects (supersonic, VTOL, boundary layer suction, etc.) should not be



This special drawing to scale of five American ballistic guided missiles gives a good impression of their comparative sizes. These and other missiles are described in the special supplement starting on page 455.

Drawing copyright "The Aeroplane"

neglected if we intend to continue manufacturing aircraft.

The "bread-and-butter" types already in service or under development cover almost all important categories in which the World's operators are interested and, overall, the U.K.'s position is not unsatisfactory. These types were listed as the V.C.10, Britannia, Comet, D.H.121, Vanguard, Viscount, Herald, Avro 748, Argosy and Britannic. The only other major type suggested by Lord Douglas as being possibly worth development from scratch is a relatively small "Viscount Replacement" turbojet.

Martin-Baker Ejection Seats

READERS of the article on aircrew comfort and survival in THE AEROPLANE for March 20 may have been given the impression that the very remarkable achievements of the Martin-Baker Aircraft Co., Ltd., in developing ejection seats to operate at speeds as low as 80 knots and at ground level are not yet available to the Royal Air Force. We much regret that such an impression should have been given, for there have been various references in THE AEROPLANE to the successful demonstration of such seats and it is the intention of the Air Ministry that the ejection seats in all R.A.F. aircraft shall be cleared for use at zero height as soon as possible.

In the same article reference was made to the development of a connector made by M.L. Aviation, Ltd. We have been informed by Martin-Baker that this connector was developed by Martin-Baker for the Ministry of Supply and that they hold a patent in connection with it.

The B.O.A.C. Year

A DEFICIT of about £4¾ million is anticipated by B.O.A.C. in the 1958-59 year, which ended on March 31. This includes £3.6 million interest paid on capital. Provision will also have to be made in the accounts for a net capital loss on the disposal of surplus aircraft. B.O.A.C.'s own operations have, in fact, approximately broken even, but the Corporation has had to face many adverse factors, including the cost of the change-over in fleets with attendant temporary duplication and costly build-up of efficiencies; the adverse results of some of the associated companies, the autumn strike at London Airport; the considerably increased interest charged on capital employed; and the very difficult trading conditions generally.

In a message to the staff, Sir Gerard d'Erlanger says that he is "much more optimistic than before" about the year 1959-60, "barring unforeseen setbacks." Capacity offered will be about 24% more than in the previous year; utilization and efficiencies are greatly improving and costs are coming down.

The year just past has been an important one for B.O.A.C. and has seen, amongst other things, the completion of the Britannia fleet; the introduction of the Comet 4; the planning of the first round-the-World service by turbine-powered aircraft; the virtual elimination of B.O.A.C.'s piston-engined types —Constellation, Argonaut and Stratocruiser; an increase in route mileage of 9.9%; and an increased share of the North Atlantic traffic into and out of the U.K. from 34.6% to 37.8%.

Less satisfactory was the drop in overall load factor of 3.6% compared with the previous year. While capacity offered increased by 14%, traffic increase was only 8.7%; on the other hand, the average traffic increase throughout the World was only 5%. A 1% improvement in the B.O.A.C. load factor is, incidentally, now worth over £1 million in revenue.

Air League Flying Scholarship

IN commemoration of its jubilee year, and as a memorial to Robert Verdon Perfect, the Air League of the British Empire has instituted the Robert Perfect Flying Scholarship. It is to be awarded annually and will comprise flying and ground training for a holder to gain a Private Pilot's Licence.

The award is open to any British subject between the ages of 17 and 21 who does not hold, and has never held, a flying licence. It is to take the form of an essay on the subject of:—

> "One of the objects for which the Air League was founded in 1909 was to disseminate knowledge and spread information showing the vital importance to the British Empire of Aerial Supremacy, upon which its commerce, communications, defence and its very existence must largely depend."
>
> Show, in not more than 5,000 words why, in your opinion, this object is as important today as it was in 1909.

Entries, accompanied by a fee of 2s. 6d., must be received by the Air League by June 22. The winner's name will be announced on August 1, and he or she must be able to start training by August 24. Flying training will be given by Airwork, Ltd., at Perth Aerodrome, and travelling expenses of up to £10 will be granted.

This year's entries will be judged by the Rev. D. L. Graham, M.A.; Air Chief Marshal Sir Ronald Ivelaw-Chapman, G.C.B., K.B.E., D.F.C., A.F.C., and Air Cdre. Sydney Smith, O.B.E., D.L.

Another Company Reorganizes

IN KEEPING with the current trend of the aircraft industry to constitute its separate activities as individual bodies, Blackburn and General Aircraft, Ltd., has announced that as from April 1 it continues solely as a holding company, responsible for general policy and finance.

Three new wholly owned subsidiaries have been formed:—

Blackburn Aircraft, Ltd., which takes over the aircraft work, buildings, land, plant and machinery at the Brough factory. The board consists of Mr. E. Turner (chairman and managing director); Mr. N. E. Rowe; Mr. T. Bancroft; Capt. E. D. G. Lewin; Mr. B. P. Laight, and Mr. R. H. Stone (secretary). Mr. Laight is chief designer (aircraft) and Mr. Stone is company secretary of Blackburn and General Aircraft, Ltd.

Blackburn Engines, Ltd., which assumes control of the engine activities and some of the trading assets at Brough. The board is constituted as Mr. E. Turner (chairman and managing); Mr. N. E. Rowe; Mr. T. Bancroft; Capt. E. D. G. Lewin; Mr. J. B. Bucher (general manager); Mr. R. H. Stone and Gp. Capt. H. J. Wilson.

Blackburn Electronics, Ltd., the board of which is Mr. A. F. Jopling (chairman); Capt. E. D. G. Lewin; Mr. N. E. Rowe; Mr. T. Bancroft; Mr. R. H. Stone; Dr. H. Fuchs (general manager), and Mr. E. G. Seath, chief engineer of Blackburn (Dumbarton), Ltd.

Air Vice-Marshal H. N. Thornton, C.B.E., who joined Blackburns as sales director in 1951, retired on March 31.

IN THE NEWS.—Some of the new Blackburn directors are, left to right, top to bottom, T. Bancroft, Capt. E. D. G. Lewin, E. G. Seath, A. F. Jopling, Gp. Capt. H. J. Wilson, Dr. H. Fuchs, R. H. Stone and J. B. Bucher.

Thor, Minuteman and Blue Streak

Washington, April 7

IN an interview at the Pentagon today the U.S. Secretary of Air, Mr. James H. Douglas, and Gen. Curtis Le May, the U.S. Vice-Chief of Air Staff, discussed U.S.A.F. missile programmes with Mr. J. R. Cownie of THE AEROPLANE's technical team. Much of the discussion centred on the Thor IRBM, whose operational status has been the subject of conflicting official reports from the U.S. and Britain.

Mr. Douglas said he believed that Thor had now reached a level of reliability at which it was a useful operational weapon. An important feature of Thor was that it should be launched within a 15-min. count-down. Thors now in Britain could not be launched within this time, but it had been approached closely during Thor test launchings at Vandenberg A.F.B. in California. An R.A.F. crew will launch Thor there shortly —possibly on April 14 or 15 when Mr. Cownie is to visit Vandenberg.

Questioned about the operational status of Thors now in Britain, Gen. Le May said that, as with aircraft, some important modifications might be applied retrospectively and others of less importance only at a later stage in production. Later Thors supplied to Britain would be modified to an improved standard. He said that Thor modifications were made to improve its reliability rather than its range, which already met design requirement.

Asked about reports that Thor production would end when current contracts ran out in about 18 months' time, Mr. Douglas said that this was undecided. He added that Thor would play an important rôle as launching booster in U.S. space and satellite programmes. But at present there were no plans for operational Thor bases apart from the four in England. (Only the position of one, at Feltwell, has been revealed officially, but it is an open secret that there are others in East Anglia and Yorkshire.)

Mr. Douglas spoke enthusiastically about the development of the solid-fuelled Minuteman, which is the first second-generation ICBM. It was likely to be the first advanced weapons system which was cheaper than its predecessors and also had operational advantages over other missiles. It would be easy to handle and could be fired rapidly from hard launching sites.

This missile would probably be ordered in large quantities. There was every advantage in using solid propellents for a missile of this type. Atlas and Titan, however, despite their liquid-propellent disadvantages, were likely to remain in service for years to come.

No future U.S.A.F. development of IRBMs was likely, but experience with solid-fuelled IRBMs would be gained from the Polaris, which was being produced for the missile-firing submarines of the U.S. Navy. In future the U.S. would rely on U.S.-based ICBMs for its main strategic-missile deterrent.

Mr. Douglas revealed that Great Britain had asked the U.S. for a missile with a longer range than Thor. He felt, however, that the ICBMs such as Minuteman had a longer range than Britain needed. He would not comment on the suggestion that Blue Streak might in due course replace Thor on sites in Britain.

Asked about the future relationship between manned aircraft and missiles, Gen. Le May said that the major part of annual expenditure was still on aircraft. He could foresee no time when manned vehicles would not be needed. The most effective force was a combination of manned and unmanned systems.

Although not definitely stated, this interview tends to confirm the belief that the U.S. has decided not to rely on overseas missile bases in future. The development of effective ICBMs and submarine-launched IRBMs will mean that the firing of U.S. missiles will not be subject to the agreement of other Governments, whose bargaining powers relative to the U.S. will be correspondingly reduced.

Canberra Interception

A CANBERRA photographic-reconnaissance aircraft of the Indian Air Force was shot down by Pakistani Sabres last week, after being intercepted near the Pakistan Army headquarters at Rawalpindi. An official Pakistan announcement said that the Canberra pilot disobeyed orders to land, and was shot down nearly 150 miles inside Pakistani territory after due warning had been given.

The Indian pilot, Sqn. Ldr. J. C. Sengupta, and his navigator parachuted from the Canberra before it crashed.

According to the Indian Defence Minister, the Canberra was flying at 47,000-48,000 ft. on aerial-survey duties and strayed into Pakistan air space because of defective navigational aids. The Pakistan Government stated, however, that the Indian pilot, who commanded a photo-reconnaissance squadron (for which eight Canberra PR.7s were procured), had admitted photographing military objectives. It added that for some months Indian Canberras had been taking advantage of their high ceilings and superior speeds to reconnoitre Pakistan territory, and repeated protests had been of no avail.

Two significant points arise. The first is that a Canberra flying at nearly 50,000 ft. was intercepted and shot down by F-86F Sabres with a normal operational ceiling of about 40,000 ft. The second is that this is believed to be the first occasion on record that aircraft of one Commonwealth country have shot down a machine of another member nation.

General Aviation News

VANGUARD PROGRESS.—By April 13 the prototype Vickers Vanguard had completed 105 hr. in about 45 test flights. Initial night flying trials were made from Bournemouth (Hurn) Airport on April 8 and a first overseas flight (to Hamburg) is planned for May 6. The first of B.E.A.'s 20 Vanguards was rolled out for engine runs on April 6 and is due to fly later this month.

FIVE NA.39s.—Something of a production record for recent years must have been created by the fact that the fifth Blackburn NA.39 naval strike aircraft has already flown: the first was airborne for the first time on April 30, 1958.

GLIDING ENTRIES.—More than 130 pilots are expected to compete in the British National Gliding Championships at Lasham from May 9 to 18. League I comprises 15 pilots seeded as possible participants in the British team in the 1960 World Gliding Championships to be held in West Germany, and 21 other experienced pilots. League II is for pilots who wish to gain competition experience or who want to qualify for the various legs of the international gliding badges. To date there are 44 entries in League II.

AUSTRALIAN FIRST.—The Millicer Air Tourer two-seat low-wing lightplane recently made its first flight at Moorabbin Airport, Victoria.

ROTARY MEETING.—An international helicopter rally is to be held at Woburn Abbey on May 10, primarily for the interest of transport operators and business executives. The public will be admitted.

ANGLO-FRENCH.—A pre-production Dassault Etendard IVM is to be fitted with a Rolls-Royce Avon 51 turbojet. It will also have a blown wing, making it possible for it to use a 103-ft. catapult.

707 TESTING.—A Boeing 707 fuselage in the water tank at Seattle has successfully completed a series of fatigue tests in which six cuts, up to 22 inches long, were made in the upper surface, window frames, floor beams and door reinforcements. The fuselage was then tested at a differential of 10.35 lb./sq. in.

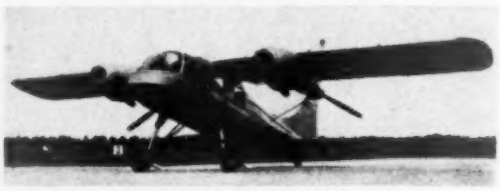
Howard Levy photograph

VIGILANT.—This view of the North American A3J-1 shows the spoiler deflectors below the wing tips and the linear bomb bay, from which the bomb is ejected rearward.

HEAVIER SKYLARK.—Through a change in the B.C.A.R., which now prescribe that specified rough-air gusts need be considered only up to speeds of 2.24 times the stalling speed, the maximum permissible weight of the Slingsby Skylark 2 sailplane has been increased from 680 lb. to 730 lb. This increase may be applied to existing aircraft.

SUPER BOMARC.—The Boeing Airplane Co. has confirmed that it is negotiating with the U.S.A.F. on a contract for continued development and manufacture of the Super Bomarc interceptor missile. More than one third of the $300 million contract has already been spent. The Super Bomarc, with an improved Marquardt ramjet engine and solid-fuel rocket booster, has a range of more than 400 n.m. and an improved Westinghouse target-seeker guidance system.

NEW GERMAN.—The Dornier Do 29 STOL aircraft has been developed from the single-engined Do 27 and uses two Lycoming GO-480 engines mounted as pushers. The span is 43 ft. 4 in. and the loaded weight 5,291 lb.



CARIBOU NEWS.—It is reported that the U.S. Army may order 250 and possibly 1,000 DHC.4 Caribou aircraft from Canada; the type is currently being tested by the Army. One of the three aircraft completed crashed in Ontario recently; both crew members safely baled out.

OCCUPATIONAL HAZARD.—According to reports from West Berlin, a number of arrests have been made at the Dresden works of the East German aircraft industry, following the crash of the BB.152 jet transport on March 5. A "basic fault in the design" is said to have been discovered, apparently leading to control difficulties.

HD.34 PRODUCTION.—The eighth and last Hurel-Dubois HD.34 air-survey aircraft built for the National Geographic Institute is now being test-flown at Villacoublay.

News About People

BROUGH TEST PILOTS. — Mr. Harold ("Tim") Wood (below, left), chief test pilot of Blackburn Aircraft, Ltd., is to retire at the end of this month. He is in his 57th year and is still at home flying a Beverley or a Meteor. He learnt to fly in the R.A.F. Reserve in 1925 and now has more than 14,000 hr. For two

years he was chief pilot of Hillman's Airways; instructed with Flying Training, Ltd., and then became chief pilot of British American Air Services until 1939, when he served with the R.A.F. He was seconded to General Aircraft in 1941 and was appointed to his present post when General Aircraft merged with Blackburn. He is succeeded as chief test pilot by Mr. D. J. Whitehead, A.F.C. (above, right), who joined Blackburn last year from the R.N.

B.E.A. BOARD MEMBERS.—Mr. R. L. Weir, O.B.E., C.A., and Sir Giles Guthrie, Bt., O.B.E., D.S.C., J.P., have been appointed to the board of British European Airways. Mr. Weir is financial controller of B.E.A. and chairman of the Airways Corporations Joint Pension Scheme, having joined B.E.A. from B.O.A.C. in 1946. Sir Giles Guthrie, who is managing director of Brown Shipley and Co., Ltd., will be best remembered as C. W. A. Scott's co-pilot in the Vega Gull which won the Portsmouth-Johannesburg race in 1936. He served with British Airways before the War, and subsequently in the Fleet Air Arm.

A B.E.A. RETIREMENT.—Mr. W. J. C. Speller, who has been technical instructor of the B.E.A. training flight for the past seven years, has now retired. "Pop" Speller has the distinction of having been a specialist on the original Gnome engine and others used before the First World War. He joined the A.I.D. in 1914 and was concerned with inspection in various official appointments from then until after the end of the Second World War.

F.A.I. AWARDS. — Paul Tissandier Diplomas have been awarded by the F.A.I. to Cdr. A. Goodfellow "for his service to British and international aviation"; to Mr. Maurice O. Imray "for his work for the ultra-light aircraft movement"; to Mr. B. A. G. Meads, M.B.E., "for his work for private aviation"; and to Mr. A. Thorburn, who "has been actively associated with the development of gliding in Scotland for more than 23 years, and who in 1938 created the Scottish Gliding Union."

CAMBRIAN CHAIRMAN. — Mr. John Morgan has been appointed chairman of Cambrian Airways. He recently succeeded Mr. John Watts in an acting capacity.

AIRCRAFT EMPLOYMENT.—During January the number of people employed in "the manufacture and repair of aircraft" amounted to 245,500, compared with 256,400 in January, 1958, and 266,600—the highest-ever peace-time figure—a year earlier.

MR. PER KAMPMANN.—One of the founders and first chairman of S.A.S., Mr. Per Kampmann died in Copenhagen on April 7. Always interested in aviation, Mr. Kampmann assisted in the reconstruction of D.D.L. Danish Airlines in 1937 and became chairman in 1940. When S.A.S. was formed in 1946 he became the first chairman and since then has been one of the three rotating chairmen.

M.o.S. POST.—The new Director-General of Aircraft Research and Development (R.A.F.) is Mr. Lewis Boddington, C.B.E. (See below).

A.R. AND D.—The M.o.S. announces that Mr. Lewis Boddington, C.B.E., M.I.Mech.E., F.R.Ae.S., has been appointed Director-General of Aircraft Research and Development (R.A.F.) in succession to Air Vice-Marshal P. S. Blockey, C.B., C.B.E., whose tour of duty in the Ministry ends in July. Since 1953 Mr. Boddington has been Director, Aircraft Research and Development (R.N.).

Commercial Aviation Affairs

MOSCOW SERVICE.—B.E.A. hopes to start its London-Moscow service during the week beginning May 11 and Aeroflot will open its reciprocal service simultaneously. Both airlines will operate two services a week via Copenhagen.

CHEAP VISCOUNT.—For the third year in succession, the Viscount 745 as operated by Capital Airlines has proved to have the cheapest aircraft-mile direct costs of any modern transport used by U.S. domestic carriers. The figure of 85.65 cents/aircraft-mile was bettered only by the DC-3 (61.18 cents) and the Lodestar (73.16 cents).

CONTINENTAL ARRANGEMENTS.—Continental Air Services of Jersey and Rotterdam will be positioning two of their aircraft at Blackbushe this year and have opened a handling unit there. A London sales office has also been opened at 117-119 Regent Street (telephone, Regent 6557). The U.K. manager of the company is Mr. L. I. Orman.

HERON OPERATOR.—On April 6, Tri-County Airways put 15-passenger de Havilland Herons into service on parts of its network in the New York city suburban area.

WEST AFRICAN BRITANNIAS.—On April 13 B.O.A.C. introduced Britannia 102s on the West African services flown by the Corporation for W.A.A.C. (Nigeria) and Ghana Airways to and from Lagos and Accra. Stratocruisers were previously used for these services.

"SKYLOAD" AT L.A.P.—B.O.A.C.'s "Skyload" unit—the organization for the swift handling of cargo bookings and inquiries—has been transferred from Airways Terminal to London Airport North, where the new telephone number is Skyport 5511.

COMET SIMULATOR. — B.O.A.C. put the Redifon Comet 4 simulator into use at the Cranebank training base, near London Airport, on March 16.

FRIENDSHIP DELIVERY.—T.A.A.'s first Fokker Friendship (VH-TFB) was christened "Abel Tasman" on April 6 in a ceremony at Schiphol, and left for Australia next day. The delivery flight was being made in easy stages, and was planned to take eight days.

VIENNA TO MANCHESTER.—On April 5 Austrian Airlines inaugurated a weekly service between Vienna and Manchester via Frankfurt. The service is operated by Viscounts.

FARE REDUCTION.—Three major Brazilian airlines—Panair, Loide Aereo and REAL S.A.—have reduced fares by 40% on DC-3 and C-46 services and by 20% on Constellation and Convair services.

K.L.M. ANNIVERSARY.—On October 7 K.L.M. will celebrate its 40th anniversary. All its aircraft will carry a special symbol for the occasion, and other celebrations which have been planned include a radio feature contest in 40 countries, special exhibitions and a jubilee concert in the Hague.

AERLINTE SHAREHOLDING. — Seaboard and Western will not now proceed with the plan to take up a 25% holding in Aerlinte (see THE AEROPLANE for January 30, 1959).

DC-6 DISPOSAL.—Frederick B. Ayer and Associates, the dealers who recently agreed to purchase 24 Convair 240s from American Airlines, last week signed a contract to buy 45 DC-6s from the same airline for $30 million, with a "first refusal" on the remaining 36 DC-6s in American Airlines' fleet. As a result of this deal, American Airlines has now arranged to sell 114 of its fleet of piston-engined transports, which totalled over 200 eighteen months ago.

MOBILE LOUNGE. — Double-deck 80-passenger buses, to be known as "mobile lounges," will be used at Washington's new airport at Chantilly to convey passengers between the terminal building and the aircraft. This arrangement—unusual at an American airport—has been adopted to reduce the distance which passengers have to walk through the terminal and fingers to the numerous gates. Passengers will board the bus from the terminal building on the upper deck and will disembark at ground level. The vehicles will have driving cabs at each end.

EXCHANGE NEWS. — Last week's *Market Report* issued by Aircraft Exchange, Inc., showed a total of 233 aircraft on offer for sale or lease. Negotiations were continuing "at an active pace," with transactions involving DC-6A and B, Constellation 049, Curtiss C-46 and Fairchild C-82 types nearing completion. Among the newest members of the Exchange are various Government organizations, including customs and excise departments and tax commissions which will use the *Market Report* to assist in official aircraft valuation.

CZECH RESULT.—During 1958, C.S.A. Czechoslovak Airlines carried 313,754 passengers and about 5,000,000 kg. of freight and mail. Figures for 1959 are expected to be over 400,000 and 6.5 million respectively.

T.W.A. RESULTS.—In 1958, T.W.A. recorded an operating loss of $375,000 ($4,539,000 in 1957). In the second half of 1958 an operating profit of $10,196,000 was recorded, this improvement being attributed to a detailed study and revisions of flight schedules, and expense control programmes.

HELIPORT CHOICE.—Welcoming the initiative shown by the L.C.C. in suggesting designated areas for heliports in London, B.E.A. has recommended that development should be in this order: first, Victoria; second, Tower Bridge; and third, King's Cross.

AUSTRALIAN BOEING.—Qantas plans to introduce its 90-seat Boeing 707-138s on the Sydney-San Francisco-New York-London route on July 29, with a scheduled time of 38 hr. for the 13,929 miles, including 11 hr. at ground stops. They will eventually fly the Qantas round-the-World route in a flying time of 51 hr. 45 min.

AER LINGUS CARGO TERMINAL.—A new terminal building accommodating all sections of the Aer Lingus cargo branch was opened at Dublin Airport on March 19. Last year Aer Lingus carried more than 9,000 tons of freight and mail compared with 3½ tons in 1936, and 27 tons in 1946. The new building is a conversion of what was formerly hangar No. 1, which now serves as the main freight shed.

HAWAIIAN ROUTE DECISION.—The C.A.B. staff recommends that Northwest Airlines' authority to serve Hawaii be put on a permanent basis, and that P.A.A.'s authority should not be renewed. Both airlines have been flying from Portland and Seattle to Honolulu on temporary authority.

ELECTRA SUCCESS. — Ansett-ANA Airways' first Lockheed Electra carried 3,331 passengers in the initial week of operation, flying four round trips daily between Melbourne and Sydney. The average load factor for the week was approximately 83%.

B.C.A.R. AMENDMENTS.—The Air Registration Board has issued a number of amendments to the British Civil Airworthiness Requirements—including an important series of changes to Section D.

Military Aviation Affairs

CADET TAKE-OVER.—Responsibility for training air cadets has been assumed by R.A.F. Flying Training Command. This picture shows the visit of the A.O.C.-in-C., Air Marshal Sir Hugh Constantine, K.B.E., C.B., D.S.O., at White Waltham recently.

FLIGHT REFUELLING.—A Bomber Command Valiant of No. 214 Sqn. has, with the assistance of air-to-air refuelling, cut ¼-hr. off the previous fastest time for a flight from the U.K. to Nairobi. On a training flight the Valiant, commanded by Flt. Lt. B. Fern, covered the distance of 4,350 miles in 7 hr. 40 min., at an average speed of 567 m.p.h. It left R.A.F. Marham at 03.36 hrs. on April 7, was refuelled over the Mediterranean at 06.00 hrs. by a Valiant Tanker of No. 214 Sqn. based at Luqa, Malta, and landed at Nairobi at 11.16 hrs.

THOR GEAR.—According to the U.S.A.F., a total of 11,534 tons of equipment, enough for two Thor missile squadrons, had been shipped to the U.K. by the end of last month. Each Thor squadron is reported now to consist of 15 missiles arranged in five groups.

FOLLAND VISITORS.—Air Marshal Sir Geoffrey Tuttle, Deputy Chief of the Air Staff, and Air Vice-Marshal W. H. Kyle, Assistant Chief of the Air Staff (Operational Requirements), visited Folland Aircraft, Ltd., on April 8 in connection with the company's contract to supply 14 Gnat Trainers for development by the R.A.F. Discussions were held with Mr. W. E. W. Petter and a mock-up of the Gnat Trainer was inspected during a tour of the works.

SAFIR ORDER.—Fourteen Saab-91C Safir four-seat trainers, designated the Sk 50, have been ordered for the R. Swedish A.F. They are powered by the 190-h.p. Lycoming O-435-A flat-six engine, and are to join the present Safir fleet of the School at Ljungbyhed.

SEA HAWK REPLACEMENT.—The West German Navy is to re-equip its Sea Hawk squadrons with F-104 Starfighters. Sea Hawks will remain in service until Starfighters have been built in Germany.

AIR DIRECTION.—H.M.S. "Lincoln," the fourth of a new type of air direction frigate for the Royal Navy, was launched on April 6.

Air Transport

The Pacific Gap

ALTHOUGH the U.S. Civil Aeronautics Board's recommendation, that Tokyo should, despite Northwest Airlines' petition, be included as a traffic stop in B.O.A.C.'s service, appears to settle the main issue in the Pacific dispute, this is not yet over. Northwest also argued that the Corporation's service would involve a serious loss to U.S. airlines and a decision on this petition had not been recommended at the time of going to press.

Thereafter the White House must give its final approval to the service; as we suggested last week, May 1 is still the earliest likely date for a resumption of B.O.A.C.'s prematurely initiated Pacific services. Meanwhile the Corporation operated its two initial return services, carrying "for free" some 120 booked passengers between San Francisco and Tokyo. Maybe, matching B.O.A.C.'s service against that of other Pacific operators and adding this to the prestige-value of turboprop equipment, these free rides will more than pay off as a propaganda exercise—however accidental this may have been.

Judging from reports of statements by representatives of Northwest and others, the situation appears to have been more complicated and rather less one-sided than the M.T.C.A. statement (quoted in last week's issue, p. 424) has suggested. Certainly it has not been made clear that the 1946 agreement sanctioned reciprocal services only between San Francisco and Hong Kong and that provision for a traffic stop at Tokyo was not added to the agreement until 1948. Nor has it been explained why (in an air transport world which is now ruled exclusively by bilaterals rather than by the principle of general freedom which people thought to be right and proper in 1946) a British carrier should consider that it has inalienable traffic rights between points in two other countries—the U.S.A. and Japan.

Meanwhile, the C.A.B. ruling on April 8, to the effect that traffic must not be carried by foreign operators between points in the U.S.A., merely gives a properly legal emphasis to the obvious. Trans World Airlines' request, however, on the same date, for permission to serve Tokyo on its eastward run and to serve Honolulu from San Francisco and Los Angeles, is obviously a part of the total story.

Inclusive Tour or Charter?

PERIODICALLY during the past decade action has been taken against independent operators and others for contraventions of the Civil Aviation and Air Corporations Acts, which give B.O.A.C., B.E.A. and their associates a monopoly of scheduled services. The result of the latest action, dismissed on April 9, may have interesting repercussions.

Apparently Hunting-Clan Air Transport, on behalf of Milbanke Tours, applied to the A.T.A.C. for permission to operate certain inclusive tours to Palma, Nice and Perpignan; these applications were refused. The prospective tourists were then told that their holiday plans would be secure if they joined the International English Language Association, for which Milbanke were the official travel agents. The proposed services thus became charter flights—duly permitted by the Acts—and the Feltham, Middlesex, magistrates' bench decided that the whole operation was perfectly legal. The passengers were bona fide members of the I.E.L.A.; Hunting-Clan were thus entitled to carry them; and Milbanke Tours were not, in any case, the carriers.

By way of a postscript it might be added that for some time before cabotage services by the independents were first approved between Kenya and London, and were started in 1952, these had been operated on a charter basis through a club or association.

Caravelle Certificates

EARLIER this month, the Sud-Aviation Caravelle was granted French and American certificates of airworthiness—on April 2 and April 8 respectively. The Caravelle, which will go into service with Air France on May 12 and S.A.S. on May 15, is the first turbojet transport of non-American design to obtain the F.A.A. airworthiness certificate, and is actually the third Sud-Aviation turbine-powered aircraft so certificated, after the Djinn and Alouette helicopters.

A Comet Incident

THE bursting of a tyre after the undercarriage had been retracted caused a de Havilland Comet to return to Beirut for a full emergency, overweight landing shortly after taking off en route for London on April 10. The tyre-burst was caused by overheating of the brakes following an abortive take-off attempt some ten minutes earlier. It caused damage to the wing skin, which in turn led to considerable vibration. The Comet returned to Beirut at once, without dumping fuel; several more tyres were burst during the landing.

Incidents of this kind have been recorded in other types of aircraft, including the Boeing 707 on an early test flight (when several tyres blew at 22,000 ft.).

Twin Pioneer Development

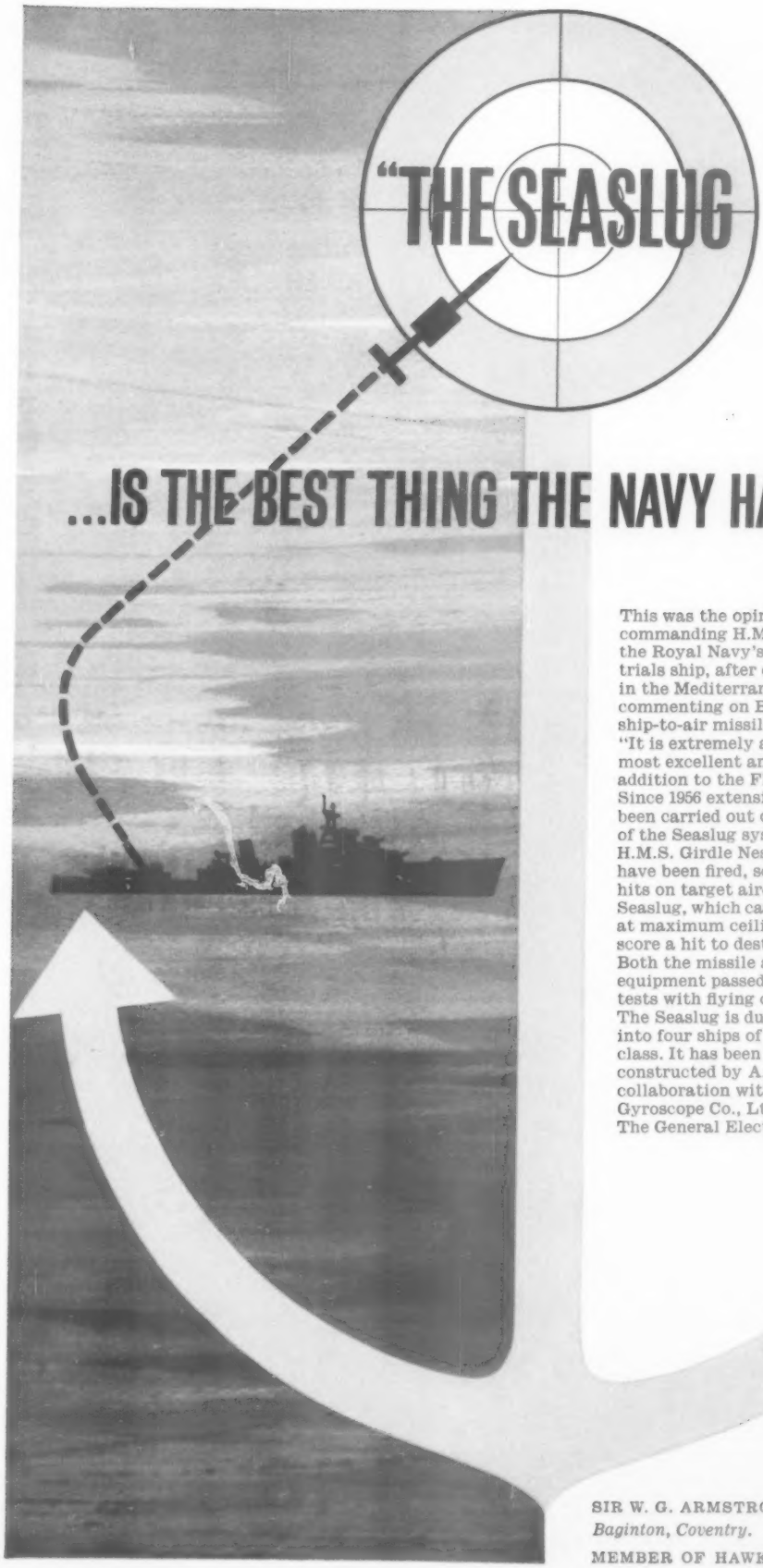
A NEW series of Twin Pioneers is now offered by Scottish Aviation, with the long-stroke 600 h.p. Alvis Leonides 531 engines. The original prototype (G-ANTP) has been flying with these engines for some time and is undergoing an accelerated certification programme. Production Twin Pioneer 3s with these engines will be available in six months' time.

Compared with the Twin Pioneer 1 with 550 h.p. Leonides 514 engines, the Series 3 is 600 lb. heavier (at 14,600 lb.); will carry 400 lb. more payload or fuel for another 130 miles; cruises 8 m.p.h. faster; has better climb on one or two engines; maintains max. take-off weight at airfield altitudes 2,000 ft. higher than previously; and reduces by 10% the direct operating costs.

The Twin Pioneer with Pratt & Whitney R-1340 engines is now known as the Series 2, and the prototype has accumulated about 100 hrs. in the certification programme. Delivery of five Twin Pioneer 2s to Philippine Air Lines will begin as soon as the certificate is obtained.

Meanwhile, fatigue testing of the specimen airframe continues. The wings, fuselage and tailplane have completed 38,000 simulated flying hours, representing a safe life of 7,600 hrs. to date, while the undercarriage has completed 50,000 simulated flying hours. The initial target for these tests is to establish a safe life of 20,000 hrs.

COMET PROVING.—The first route-proving flight by Aerolineas Argentinas Comet 4 between Buenos Aires (where this picture was taken) and New York was completed on April 8 in a flying time of 13 hr. 10 min. for the 6,090 st. mile journey via Rio de Janeiro and Trinidad. Before making the return flight the Comet is visiting Montreal, Boston and Philadelphia. A third Argentine Comet 4, LV-PLP, will be delivered later this month.



"THE SEASLUG ...IS THE BEST THING THE NAVY HAS EVER HAD"

This was the opinion of the officer commanding H.M.S. Girdle Ness, the Royal Navy's guided weapons trials ship, after extensive trials in the Mediterranean. He was commenting on Britain's first ship-to-air missile and he added: "It is extremely accurate–a most excellent and necessary addition to the Fleet armoury". Since 1956 extensive trials have been carried out on every part of the Seaslug system aboard H.M.S. Girdle Ness. Many missiles have been fired, scoring direct hits on target aircraft–though the Seaslug, which can engage bombers at maximum ceiling, need not score a hit to destroy its objective. Both the missile and the shipborne equipment passed the rigorous tests with flying colours.
The Seaslug is due to be fitted into four ships of the new County class. It has been designed and constructed by A.W.A. in collaboration with Sperry Gyroscope Co., Ltd., and The General Electric Co., Ltd.

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD.
Baginton, Coventry.
MEMBER OF HAWKER SIDDELEY AVIATION DIVISION

EMPHASIS ON MOBILITY

Nowadays changes in strategical concept, the type of defence required, and the very nature and direction of any hostile threat, occur with bewildering rapidity. Deployments undertaken at enormous cost are found to be no longer required. Defences need re-siting. The exact location of static sites becomes common-knowledge. Formations and units in the field need defending.

TO ALL THESE PROBLEMS, THE ANSWER IS

THE 'ENGLISH ELECTRIC' THUNDERBIRD

The ENGLISH ELECTRIC 'Thunderbird', now in production, is a completely mobile ground-to-air weapon system. Its mobility provides the flexibility which is becoming of ever increasing importance in future air defence . . . . **AND THE ECONOMY AS WELL.**

A MEMBER OF THE ENGLISH ELECTRIC AVIATION GROUP

GW218

Gibraltar's New Terminal

THE average person thinks of Gibraltar (Gibel Tarik for its seven centuries in Moorish hands) either as the Rock or as a military-cum-tourist staging post. As the Rock it may be a mysteriously essential military stronghold to which immense cloak-and-dagger engineering feats have been applied since the original tunnelling in the 18th century; as Gibraltar it has more recently become a take-off point for travels in Spain and North Africa, and a tourist centre in its own right.

However interesting the Rock may be, as such, with its excavated galleries and its runway laid across the isthmus which separates it from the Spanish mainland and out into the harbour, Gibraltar has become, during the past few years, a busy and important place for the airlines—and for British European Airways and Gibraltar Airways in particular. During 1958 there were 62,265 passenger movements by air through this point, with about 1,600 civil aircraft movements—mainly by B.E.A./G.A., Royal Air Maroc, Hunting-Clan and Transair.

B.E.A., which started operations between London and Gibraltar with DC-3s in March, 1946, and later with Vikings through Bordeaux and Madrid, carried 2,509 passengers in 1951-52 and 11,867 in 1957-58. Through Viscount services were started in the winter of 1953-54. The Corporation is now operating 12 round trips weekly by day and night—cheap night services were started in June, 1955—and, in co-operation with Gibraltar Airways whose services are operated by B.E.A., eight London services per week to and from Tangier, with two via Madrid. This year the DC-3 extension services between Gibraltar and Tangier have been dropped in favour of services in which Viscounts fly through with a stop at Gibraltar before the 11-minute flight to Tangier. Royal Air Maroc operate to Gibraltar from Tangier; Hunting-Clan fly weekly Colonial Coach services from London; and Transair (see THE AEROPLANE of October 4, 1957) operate trooping flights.

Photographs copyright "The Aeroplane"

The new passenger terminal for Gibraltar's North Front service/civil aerodrome which was opened last week.

The previously existing passenger facilities provided by the R.A.F., and designed primarily for military purposes, have for long been both inadequate and unattractive for a major civilian passenger centre. But the airport is a military base and the difficulty has been that of finding the means of paying for a new terminal. These were eventually approved, from Gibraltar funds, and in 12 months from the design stage a new building has been brought into being at a cost of little over £40,000. This building was officially opened on April 8 and was brought into active use on the same afternoon. It is a simple and effective terminal in the modern architectural vernacular with the capacity for channel-doubling during heavy-traffic periods, in or out, and for expansion as necessary. Gibraltar now has a gateway to match its growing importance as a civil air-traffic centre.

A Boeing Incident Explained

WHEN the C.A.B. hearing into the Boeing 707's 29,000-ft. dive on February 3 was resumed in Seattle on April 1, the Boeing Airplane Co. took the unusual course of making a formal statement indicating the probable cause of the accident. This statement, read by Bryce L. Carter, staff engineer for airworthiness, said that the accident would not have occurred if the Mach trim system had been in operation when the autopilot disconnected, or if the crew had been properly attentive. The full text of the statement follows:—

> "Based on substantial accumulated experience, Boeing designed the 707 airplanes with greatly improved features for automatically controlling the airplane in flight. Special emphasis was placed on preventing inadvertent overspeed even in the event of single or multiple failures of the automatic controls. It was recognized that certain safety features were highly desirable, such as Mach warning and the autopilot comparator which provides automatic disconnect in the event of autopilot malfunction. Standard procedure for training of airline crews includes demonstration of limiting operational speeds, recognition of buffet warning and normal recovery to prevent excessive overspeed.
>
> "The evidence in this case indicates that the autopilot disconnected during the flight prior to the Gander accident. Autopilot behaviour of this nature on the flight to Gander in itself should not have resulted in excessive overspeed and the results thereof. As brought out in earlier testimony by Boeing personnel, the Mach trim system was installed specifically to provide positive longitudinal stability at speeds higher than the cruising speed on this flight. If the Mach trim system had been in operation at the time of autopilot disconnect just prior to the accident, or if the crew had been properly attentive, it is Boeing's opinion that the accident would not have occurred."

According to reports of the earlier stages of the hearing, held in New York during March (see THE AEROPLANE for April 3, p. 399), the crew testified that the switch actuating the Mach trim system was found to be off after the aircraft was brought under control. Neither pilot remembered turning this switch off; it normally would have been turned on soon after take-off.

A Boeing structural integrity engineer, Harold J. Hayden, said that the 707 was subjected to up to 5*g* during its dive, and that the pilots probably had to apply a stick force of up to 300 or 400 lb. to pull it out of its spiral dive. The damage sustained by the 707 consisted of skin wrinkles, aileron and wing fillet damage and fuel-cell leaks. A slight "set" had been put into the wings, amounting to 2½ in. upwards at the tips, and the leading edges had been twisted downwards slightly. The aircraft (N712PA) has been repaired by Boeing at Seattle and is now back in service with Pan American on the North Atlantic.

The precise sequence of events following the disconnecting of the Bendix PB-20 autopilot is still not clear. With neither the autopilot nor the Mach trim system in operation, the 707 may have gone into a shallow dive, with rapidly accelerating airspeed and a wing drop through compressibility effects. This could soon have led to the tight spiral dive which is known to have occurred.

At 35,000 ft. and a weight of probably not much less than 200,000 lb. the 707 would have been close to the so-called "coffin corner," where the speeds of the low-speed stall and the compressibility stall coincide, and quite a small increase in speed would have been sufficient to cause the loss of control. In the case of the B-47 bomber (with the same basic wing as the 707) at 200,000 lb., the two stalls coincide at Mach 0.75 at 36,000 ft.

It is interesting to recall an accident to a B-47 (which was first recorded in THE AEROPLANE for January 18, 1957) in which the circumstances were not unlike those affecting the 707. The B-47, at a weight of 150,000 lb., was climbing at 2,200 ft./min. with an I.A.S. of 350 knots (420 knots T.A.S.). The pilot levelled off momentarily at 10,000 ft., and with no adjustment the speed began to increase at the rate of 1 knot/sec., sufficient to bring the aircraft into the critical zone within a minute. While the pilot was tuning the ADF, for not more than 30 sec., the aircraft continued to accelerate, and when he looked up it was in a dive of about 20° at an angle of bank of 25-30°, and an I.A.S. of 450 knots. Despite the application of full right aileron, the B-47 steepened its spiral dive until it crashed; the pilot ejected and survived.

Proper corrective action, in this case, would have been to cut power and apply a back pressure of 125-150 lb. on the stick, to effect a 3*g* recovery. At certain angles of pitch and bank, however, the control forces of the manual elevator in the B-47 are so high as to make recovery from a sufficiently steep spiral dive impossible. The situation in the 707 is not directly comparable since the latter has airbrakes and the B-47 does not. In this connection, a Boeing aerodynamics engineer, Joseph F. Sutter, said at the hearing that it would have helped recovery if the 707's speed brakes had been applied and engine power had been cut.

The Fighting Services

Air Rank Appointments

AIR VICE-MARSHAL R. A. RAMSAY RAE, O.B.E., is to become A.O.C., No. 224 Group, Far East Air Force, on June 15 in succession to Air Vice-Marshal V. E. Hancock, C.B., C.B.E., D.F.C., R.A.A.F. Deputy Air Secretary at the Air Ministry since July, 1957, Air Vice-Marshal Ramsay Rae previously commanded A. and A.E.E., Boscombe Down. From September, 1954, to April, 1955, he served as Deputy Director of Flying Training at the Air Ministry.

Group Captain S. W. B. Menaul, C.B.E., D.F.C., A.F.C., officer commanding R.A.F. Lindholme since 1957, has taken up the post of Air Officer in charge of Administration, British Forces Arabian Peninsula, with the acting rank of Air Cdre. Appointed a Deputy Director of Operations at the Air Ministry in 1953, Gp. Capt. Menaul led an Air Task Force for the third series of British atomic tests in the Monte Bello Islands in 1956.

Wright Jubilee Trophy

FLYING instructors from Flying Training Command units are to compete in the sixth annual individual aerobatics contest for the Wright Jubilee Trophy at the Central Flying School, R.A.F. Little Rissington, on April 30. The Trophy, a silver cup, was presented to the Service in 1953 by the R.A.F. Association to commemorate the 50th anniversary of powered flight.

It is competed for by flying instructors nominated to represent the R.A.F. College, Cranwell; the All-Weather Jet Refresher School, Strubby; No. 1 Flying Training School, Linton-on-Ouse; No. 5 Flying Training School, Oakington; No. 7 Flying Training School, Valley; and No. 8 Flying Training School, Swinderby. Each pilot performs a compulsory sequence of set aerobatics and is allowed 2 min. for voluntary individual manœuvres. A panel of four officers from the supervisory staff of the Central Flying School will judge the contest.

Australian Squadron Presentation

WHEN No. 601 (County of London) Squadron, R.Aux.A.F., was disbanded on March 10, 1957, it was decided that its winged sword emblem should be given to a unit that was still actively flying, and the obvious choice was its sister squadron, No. 24 (City of Adelaide) Fighter Squadron, R.A.A.F.

At a recent ceremony, His Excellency Air Vice-Marshal Sir Robert Allingham George, K.C.V.O., K.B.E., C.B., M.C., Governor of South Australia, presented the emblem to the Australian squadron. It was accepted on its behalf by Gp. Capt. R. M. Rechner, D.F.C., A.D.C., who is the Citizen Air Force member of the Air Board and who was responsible for the affiliation of the two squadrons.

No. 601 Squadron had a distinguished record during the Battle of Britain, flying Hurricanes. At the time of its disbandment it was equipped with Meteors.

R.A.A.F. OCCASION.—As reported on this page, H.E. Air Vice-Marshal Sir Robert Allingham George, Governor of South Australia, recently presented No. 601 Squadron's emblem to No. 24 Squadron, R.A.A.F. Sir Robert is seen here talking to A.C. E. Lunn, ex-member of No. 601 Squadron. Behind the Governor are Flt. Lt. W. Scott, Flt. Lt. R. Frost and Sqn. Ldr. S. Bradford, D.F.C., commanding No. 24 Squadron.

SQUADRONS MERGE.—On April 1 at Eastleigh, Nairobi, the Standard of No. 208 Squadron, which has operated Hunter F.6s from Cyprus for the past year, was handed over to a new Venom squadron, No. 142 (Sqn. Ldr. R. Ramirez), which is to be based at Khormaksar, Aden (THE AEROPLANE, March 27, 1959). Flt. Lt. R. J. M. David (right) is seen handing over the Standard to Flt. Lt. P. G. Biddiscombe, of No. 142 Squadron, which has now become No. 208.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Air Ministry: Gp. Capt. T. P. F. Trudgian, O.B.E., to the Department of the Air Member for Personnel; Gp. Capt. R. J. H. De Brett to the Department of the C.A.S.; Wg. Cdr. H. E. Angell, D.F.C., to the Department of the Air Member for Supply and Organization; Sq. Ldr. R. J. K. Baker, M.B.E., to the Department of the Air Member for Personnel (with acting rank of Wg. Cdr.).

Fighter Command: Sqn. Ldr. J. C. Cox to R.A.F. Odiham to command the Flying Wing (with acting rank of Wg. Cdr.).

Bomber Command: Wg. Cdr. T. N. Staples, D.F.M., to R.A.F. Wittering to command the Administrative Wing; Wg. Cdr. A. F. Fegen to R.A.F. Finningley to command the Administrative Wing; Wg. Cdr. L. J. Morris to Headquarters as Command Catering Officer; Sqn. Ldr. G. Greenfield to the Central Reconnaissance Establishment for Operations duties.

Coastal Command: Wg. Cdr. W. G. K. Gorrie, D.F.C., to R.A.F. St. Mawgan to command the Administrative Wing.

Flying Training Command: Gp. Capt. P. H. Legg, O.B.E., to Headquarters as Command Education Officer; Wg. Cdr. S. R. Hyland, O.B.E., D.F.C., A.F.C., to Headquarters for Planning duties; Wg. Cdr. J. C. Stevenson to R.A.F. White Waltham to command; Wg. Cdr. F. E. Evans to Headquarters for Accounts duties; Wg. Cdr. J. R. Ritchie, A.F.C., to Headquarters for Organization duties.

Technical Training Command: Gp. Capt. A. B. Riall, C.B.E., to Headquarters as Senior Ground Defence Staff Officer; Gp. Capt. A. G. Douglas, C.B.E., M.C., to the R.A.F. Regiment Depot, Catterick, to command; Wg. Cdr. E. G. Rands to R.A.F. St. Athan as Senior Administration Officer (with acting rank of Gp. Capt.).

Maintenance Command: Gp. Capt. T. King to Headquarters No. 40 Group, for Operations duties; Wg. Cdr. W. A. Jones to Headquarters No. 40 Group, for Technical Staff duties.

R.A.F. Germany (2nd T.A.F.): Wg. Cdr. E. D. Levien, D.S.O., D.F.C., to Headquarters for Administrative Staff duties; Wg. Cdr. J. C. Graham, D.F.C., to R.A.F. Wildenrath to command the Administrative wing.

Middle East Air Force: Wg. Cdr. E. R. Bell, M.V.O., D.F.C., A.F.C., to Headquarters for Air Plans duties.

Far East Air Force: Wg. Cdr. R. C. Rotherham, O.B.E., D.F.C., to R.A.F. Kai Tak to command; Wg. Cdr. J. F. Powell, O.B.E., M.A., to Headquarters for Education duties.

...and now we've increased the payload and range, too

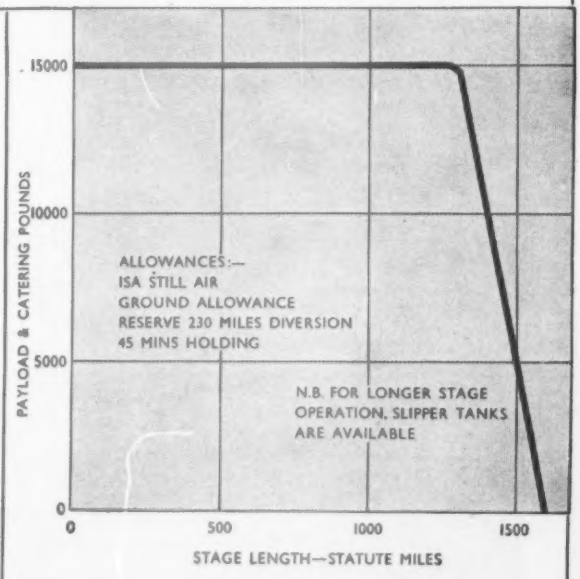
Since the original Viscount 810 design, both its payload and range have been increased. That means even higher density operation and, of course, lower operating costs. The graph speaks for itself. The results are even more impressive. Seat-mile costs can be reduced by more than 10% on all stages. On long haul the saving is up to 23%. In terms of earning power this gives an increase of 15% to 30% according to range.

The new Payload and Range details

- ★ **Take-off weight now 72,500 lb (up 5,000 lb)**
- ★ **Landing weight up by 2,000 lb. zero fuel weight and payload increased by 3,000 lb**
- ★ **Maximum-payload range increased from 800 to over 1,200 miles**

Plus

- ★ 365 m.p.h. cruising speed. When re-engined with more powerful Darts, 400 m.p.h.
- ★ Backed by Vickers/Rolls-Royce jet-prop experience of over 300 Viscounts in service with 40 airlines
- ★ Viscount 810 is already in service with or on order for Continental Air Lines, Lufthansa, South African Airways, Ansett-A.N.A., Airwork, Cubana, Hunting-Clan, Pakistan International Airlines, T.A.A. and V.A.S.P.



VICKERS VISCOUNT 810/840

FOUR ROLLS-ROYCE DART JET-PROP ENGINES

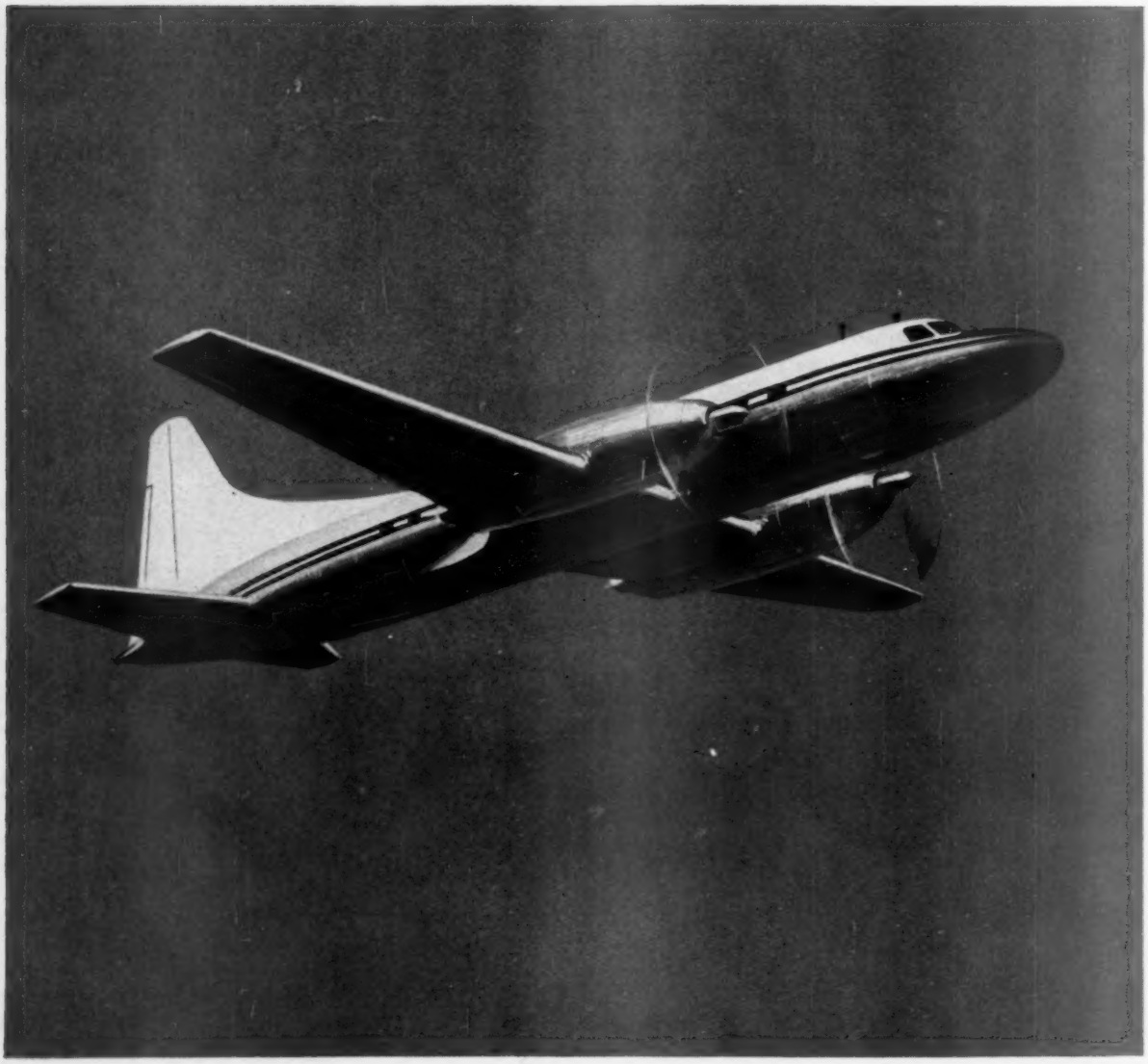
Fastest and most economical medium-sized airliner in the world

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY ENGLAND

TGA AT609A

Introducing a new standard of

FIRST jet-prop aircraft
with engines specifically
designed for use on fast,
multi-stop, inter-city services;



inter-city airline transport:

FIRST with adequate growth potential for increasing traffic densities on short-to-medium routes.

CANADAIR CONVAIR 540

JET-PROP AIRLINER

The "540" combines the airframe of the world-renowned Convair "440" Series . . . proved in over 6,000,000 hours of service . . . with Napier Eland 3,500 e.s.h.p. jet-prop engines. The result is a fast, flexible new aircraft that has excellent performance characteristics and earning power.

FIRST — The Canadair-Convair 540 is the *first* airliner with engines specifically designed for the rigorous up-and-down life of short stage operations, and offers a new standard of economy.

FIRST — The *first* airliner with such great growth potential. Standard seating capacity of 48 can be increased by 20% to 58, still with three feet of leg room per seat. This growth potential, *plus* the proved performance of the airframe, means a useful life of at least 15 years.

Here are more examples of its outstanding characteristics:

- FASTEST IN ITS FIELD—Up to 340 m.p.h. at 20,000 ft.
- GREAT FLEXIBILITY—Equally at home in a series of short hops as it is on medium ranges and at all altitudes up to 20,000 feet . . . operates out of all close-in and most smaller fields.
- LOW OPERATING COSTS—As economical as a piston aircraft in stages as short as 80 miles . . . simplified maintenance lowers cost of training.
- EXTRA FUEL CAPACITY—Sufficient for most routes terminal to terminal...three 350-mile stages without re-fuelling and without weight or space limitations.
- GOOD EARNING ABILITY—Profitable even with moderate payloads.
- CARGO AND EXPRESS CAPACITY—An additional profit opportunity: 788 cubic feet of easily accessible space.
- QUICK TURNAROUND—Self-service baggage racks and self-contained stairway speed departures and arrivals.

MOST IMPORTANT TO YOU

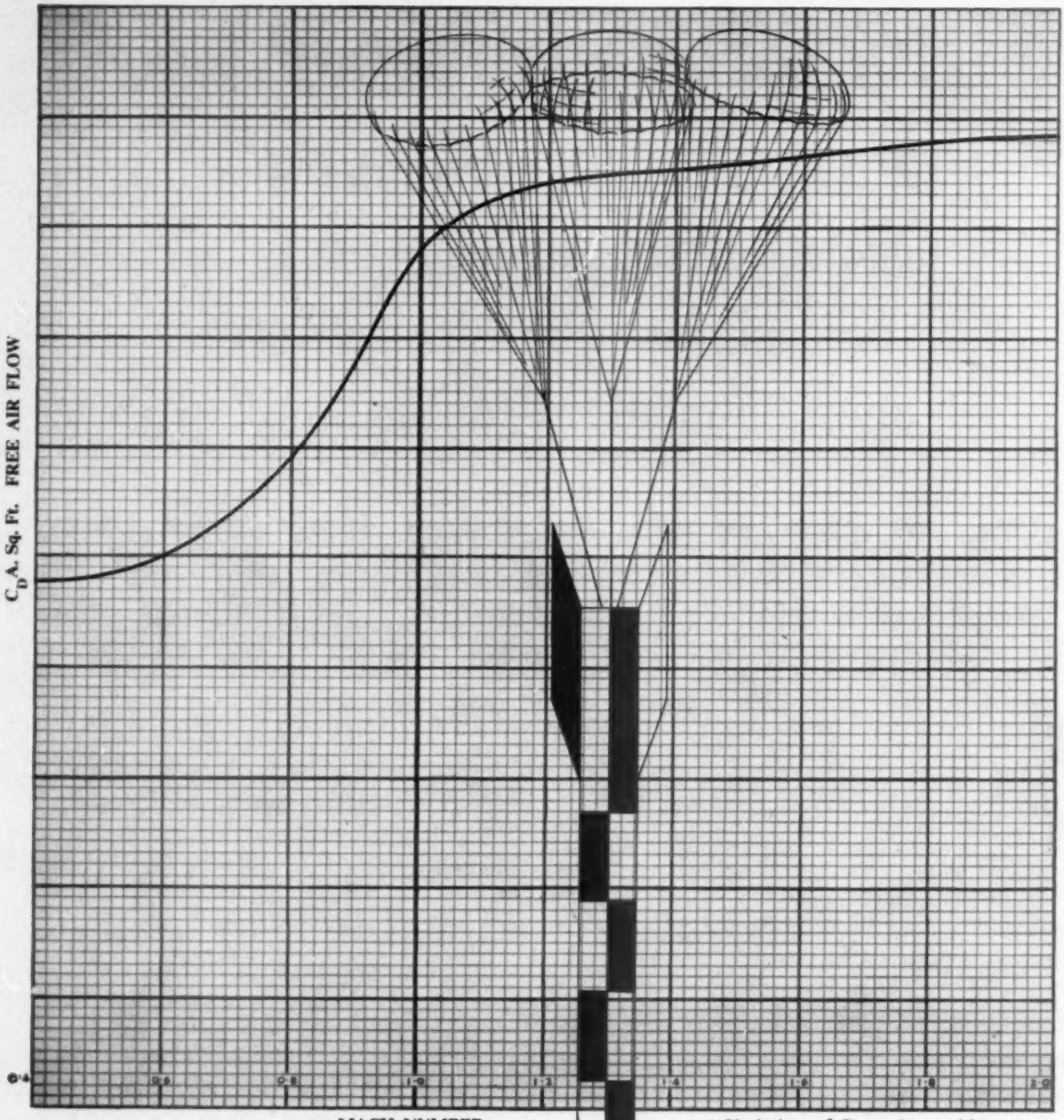
The Canadair-Convair 540 is a product of the combined experience and facilities of two of the world's great aircraft producers—Canadair Limited of Canada and Convair — both members of the General Dynamics family of companies.

Your request for detailed information on the Canadair-Convair 540 will receive our immediate attention: contact our European representative: J. H. Davis, Princes House, 190 Piccadilly, London, W.1., England.

CANADAIR, Montreal, Canada

Canadair is a subsidiary of General Dynamics Corporation

CA 59-540-21 UKT



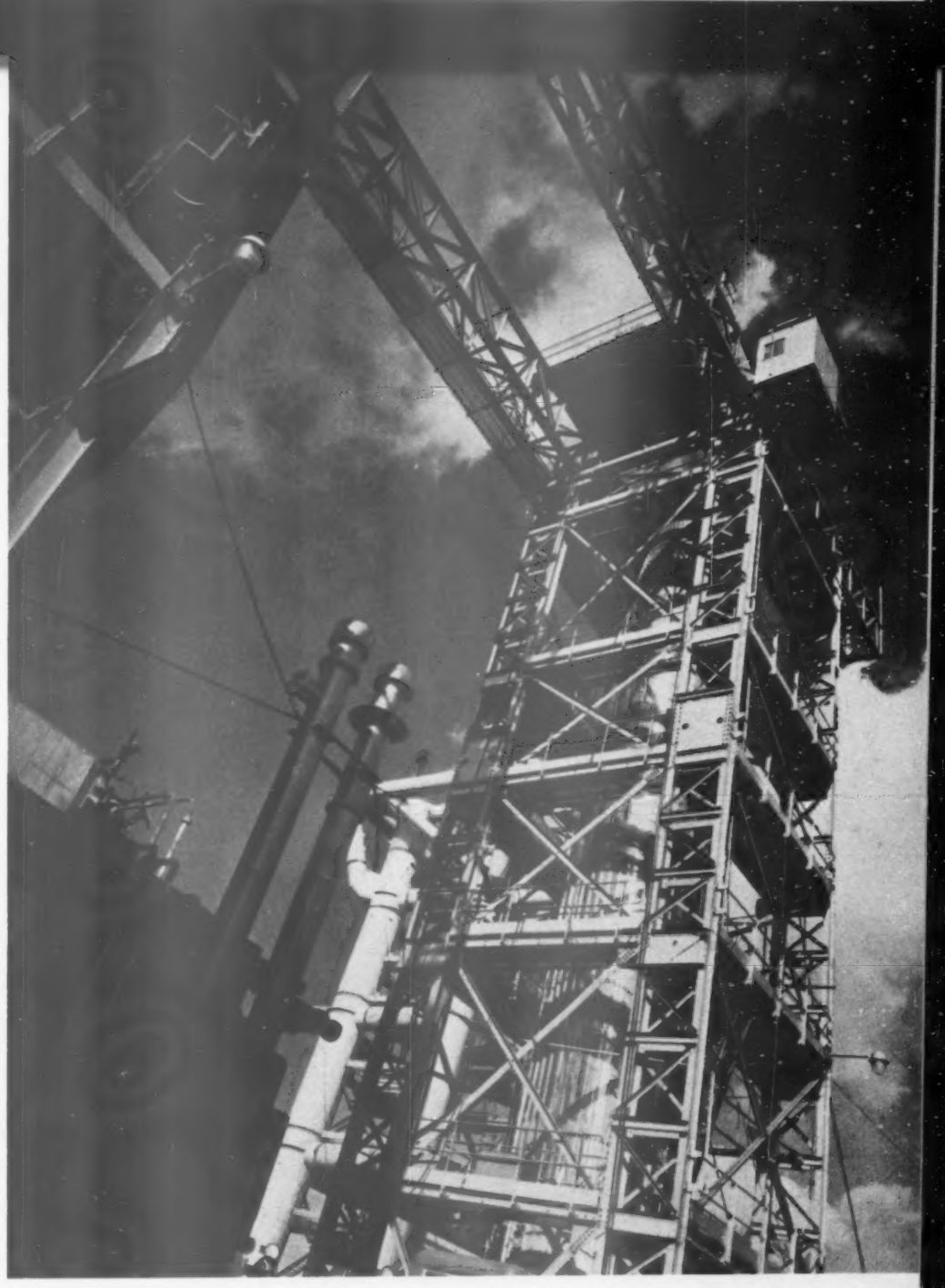
Variation of Drag Area with Mach No.

Performance curve for G.Q. Supersonic Parachute.

Leaders in Parachute development — G.Q. are designers of supersonic recovery parachutes, the performance of which has been shown in practice to relate closely to the theoretical design.

G.Q.

G.Q. PARACHUTE CO. LTD · STADIUM WORKS · WOKING SURREY Telephone : WOKING 2277



Part of the static test-rig installation at Hatfield for the development of the de Havilland Blue Streak long-range ballistic missile, which can be discerned among the girders.

MISSILES AND ASTRONAUTICS

No more than a decade ago, a guided missile was regarded as something to be discussed only in the most guarded way; now they are commonplace. Likewise, until comparatively recently the word astronautics represented the unknown quantity of some future science.

It is, perhaps, a measure of the remarkable progress made in these technologies that a stage has already been reached when developments in one have made possible the initial realization of the other. This progress is surveyed in the articles and summaries which are in the following 27 pages covering the allied subjects of missiles and astronautics.

Missiles and Astronautics . . . .

Prospects for British Spaceflight

By Kenneth W. Gatland*

MANY factors influence Britain's chances of entering the spaceflight field, but the crux of the problem is obviously financial. According to unofficial estimates, an annual expenditure of £50m. to £100m. could see a useful beginning. Can we afford it?

Those who believe we can't suggest that the money would be more wisely spent on medical research, education, or 101 other equally worthy causes. It is all very well, they say, to argue that the Government should put up the money—but, when all has been said, it is the long-suffering British taxpayer who must find it. If, in addition to all our other heavy commitments, millions are now to be spent on spaceflight, then either the money must be raised by increased taxation or some other national interest must be abandoned or curtailed.

The advocates of a space programme, on the other hand, insist that the effort must be made despite the cost. Britain pioneered jet propulsion, television, radar and nuclear energy, and, if we are to have any stake in the future, we cannot stand aside from space research.

The trouble is that research becomes increasingly expensive with each new advance of the technological frontier. Whereas in the pioneering days of aviation, one or two men working with meagre resources could make practical—and quite significant—contributions to the science of flight, Space Age development requires capital expenditure of quite staggering proportions. Clearly, there will be no back-yard spaceships!

From economic considerations alone, it is clear that we cannot compete with Russia and America on anything like equal terms. And yet, if we are to retain our time-honoured position as leaders in science and discovery, space research is something we cannot ignore.

If we did, we should be cutting ourselves off from a whole future of science and technology. Inevitably this would lead to our dependence on other Powers, for sooner or later we should want to benefit from the many new techniques derived; for example, from FM radio and TV relay satellites, weather and reconnaissance satellites, skip aircraft, orbital winged vehicles, etc., if not complete new weapon systems following after the long-range ballistic missile. Unless we keep abreast of astronautical development, we may quickly find ourselves in a backwater of aviation, devoid of important new industries born of the Space Age. This, in turn, could not fail to weaken our influence in international affairs.

In this situation we should be on a par with those European nations which, in the early days of this century, failed to keep abreast of developments in aviation, and which today have to import their aircraft.

How then could we make a start? Perhaps one might begin

(*Continued on page 457*)

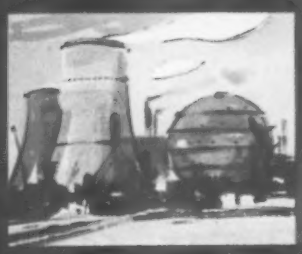
* Vice-chairman, British Interplanetary Society.

The World's largest radio telescope at Jodrell Bank, Cheshire. When this photograph was taken attempts were being made to track one of Russia's Sputniks.

Delaney Gallay LTD

HEAT EXCHANGERS

We have vast experience in the design and construction of heat exchangers in light alloy and stainless steel. We shall be glad to help you in this field too.



1 The insulant used—Thermoflex RF 300—offers a degree of protection against radiation.

2 Completely encased in stainless steel, they require no maintenance and are not easily damaged.

Delaney Gallay Thermal Insulation Blankets can be made to fit both simple and complex shapes. The stainless steel sheathing is dimpled for maximum rigidity, and can be completely sealed against the ingress of liquids if necessary.

They are designed for easy fitting and removal, and can be supplied with apertures to accommodate controls.

If you would like further information for their application to guided missiles, please contact us. We shall be happy to supply it.

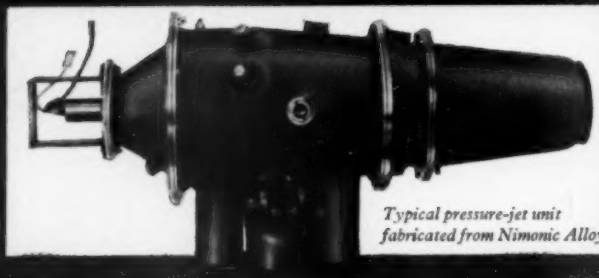
Experts in Heat Exchange & Heat Insulation for over 40 years.

Vulcan Works, Edgware Road, London, N.W.2. Tel: GLAdstone 2201

For top 'tip' performance . . .

An exacting combination of qualities is required of the pressure-jets which power the rotor of the Fairey Rotodyne. They must provide high thrust and be as compact as possible to reduce drag. This calls for abnormally high operating temperatures in a structure which must also withstand large centrifugal and pressure loads.

. . . Fairey use NIMONIC* Alloys



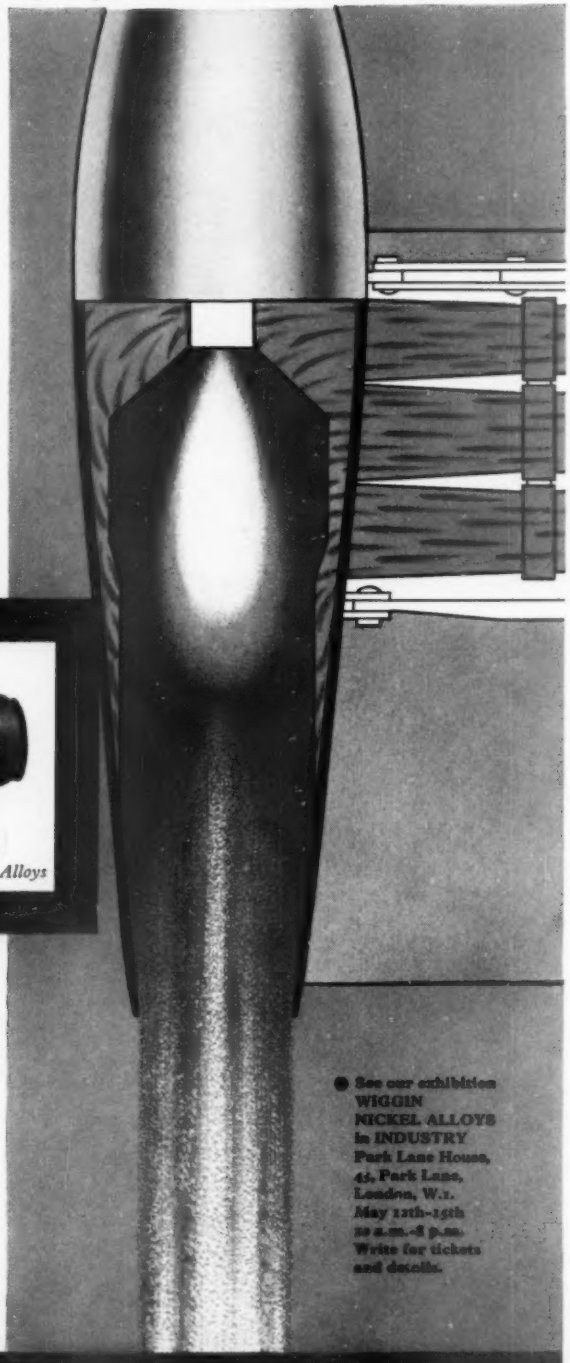
Typical pressure-jet unit fabricated from Nimonic Alloys

The necessary strength and heat-resistance are ensured by fabricating the jets from Nimonic Alloys. Nimonic 80A rings welded to sheet of the same alloy comprise the main body and housing. The liner is of Nimonic 75 and certain very highly-stressed components are machined from Nimonic 90.

Write for a free copy of our booklet 'Wiggin Nickel Alloys in Aircraft'.

'NIMONIC' IS A REGISTERED TRADE MARK

HENRY WIGGIN & CO LTD · WIGGIN STREET · BIRMINGHAM 16



● See our exhibition WIGGIN NICKEL ALLOYS in INDUSTRY Park Lane House, 45, Park Lane, London, W.1. May 12th–15th 10 a.m.–8 p.m. Write for tickets and details.

* Used for the moving blades of every British gas turbine

TGA 119

Missiles and Astronautics . . . .

(*Continued from page 456*)

by pointing out that, even without an official space policy, Britain is not entirely a spectator in this field. Indeed, outside the two other major World Powers, we are doing more than the rest of the World put together when various unrelated activities are brought to a common focus.

The observational and computational work carried out with the Sputniks by the Royal Aircraft Establishment has won high praise, not least from the Russians whose orbit measurements have often been inferior to our own. The work of Professor Lovell and the Jodrell Bank Experimental Station in the tracking of satellites and space probes is a great tribute to British enterprise, and one that has brought us much prestige.

In the field of rocketry, the Skylark upper-atmosphere research programme sponsored by the Royal Society's Gassiot Committee, in collaboration with the R.A.E., and six university groups in the U.K., has contributed new information on the structure of the atmosphere up to altitudes of 100 miles or so. In the age of Sputniks and lunar probes, this type of research may not make headlines but it is nevertheless vital to the step-by-step analysis that the World's scientists are making of the properties of the high atmosphere.

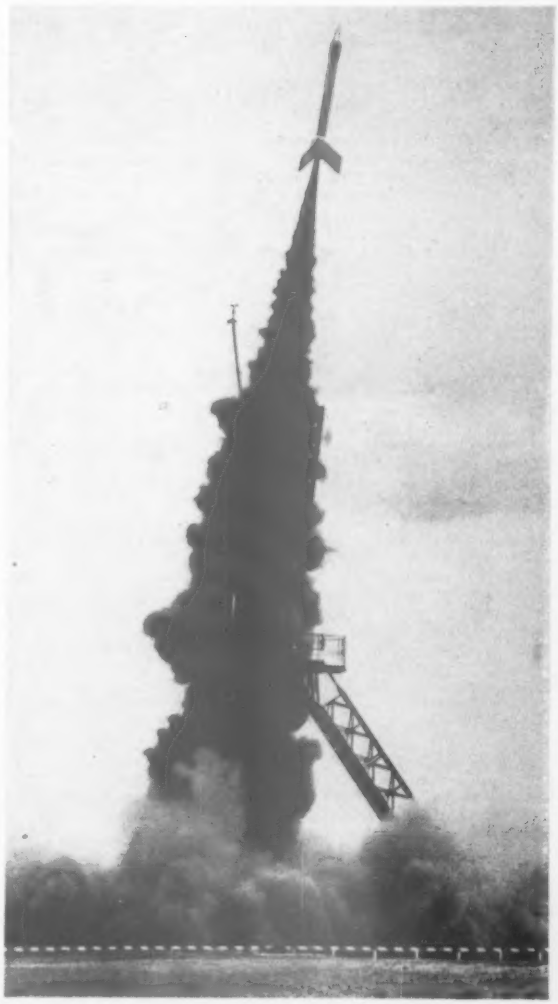
It says much for the initiative of the Hawker Siddeley Group that they have a small team of engineers working on re-entry problems related to manned spaceflight. The work at present is limited to the wind-tunnel drawing office of Armstrong Whitworth Aircraft, using the company's 3.0-in. diameter shock-tube, and a small group of mathematicians. And although the end-product will be a brochure rather than a three-dimensional space-vehicle, at least this may help to stimulate interest when it is submitted for Government consideration later this year.

While on the subject of manned spaceflight, we must not overlook the excellent work undertaken by the R.A.F. Institute of Aviation Medicine at Farnborough, whose researches into the physiological and psychological aspects of flight at high altitudes, and near the limits of physical endurance, bear a special relationship to the problems of astronautics.

Thus, there already exists in Great Britain a fairly extensive interest in the problems of spaceflight, quite apart from a well-established missiles industry which naturally would play a leading part in any space programme that may subsequently emerge.

The Government's reticence to sponsor an official programme has come in for a good deal of criticism in recent months, from individual British scientists, engineers and leading industrialists, who feel that valuable time is being wasted in a field which sooner or later we *must* enter.

However the prospective space programme is arranged, we must learn to do things cheaply—and this means careful planning. Under no circumstances can we afford the American method of "backing every horse in the race, both ways"; what we choose to develop must be right first time, and there can be no question of costly alternative programmes.



An official Australian photograph of a Skylark launching at Woomera in July, 1957.

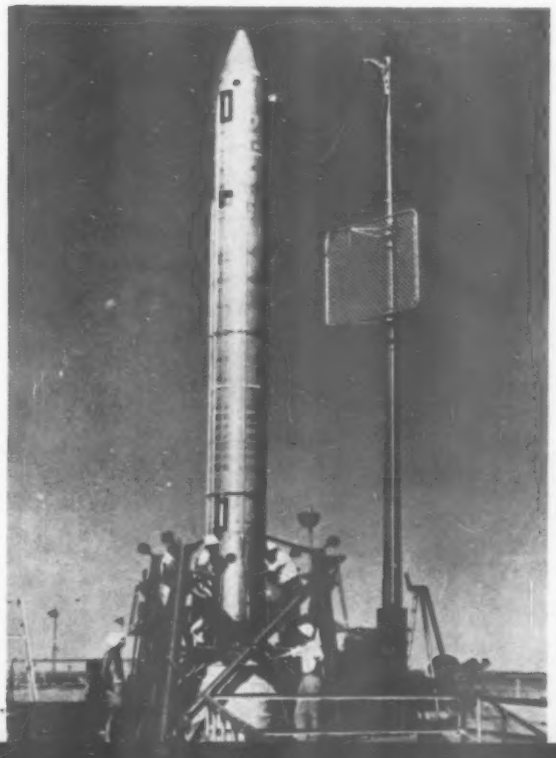
The fact that we have been able to produce—and successfully launch first time—a rocket like the Black Knight on a "shoe-string" budget of less than £5 million has been something of an eye-opener to many people. Although this is a small rocket compared with some of those produced in America, it is nevertheless a clear indication of what can be done if we plan wisely.

The cheapest way for us to enter the field would obviously be to adapt the rocket vehicles we already have under development, and it is abundantly clear that a useful programme of research could be directly developed from work already in progress, perhaps on the lines of the British Interplanetary Society proposals published last July. Briefly, these envisaged:—

(1) Extension of the successful Skylark upper atmosphere programme.

(2) Development of clustered and staged solid-rockets to carry research instruments beyond the 90 to 120 miles limit of the Skylark rockets. This was linked with a suggestion that large plastic balloons might be used in conjunction with rockets, similar in fact to the Farside experiments performed in 1957 by the U.S.A.F. at Eniwetok Atoll. (This technique would be especially suited to countries with small technical and economic resources and, indeed, India is reported to be considering such a project.)

(3) Adaptation of rocket test-vehicles built for research into ballistic re-entry problems (e.g. Black Knight). Upper staging being developed for this rocket will extend the



A Black Knight being prepared for firing at Woomera.

Missiles and Astronautics . . . .

vertical range from 350 to 1,500 miles, carrying it into the fringe areas of the inner Van Allen radiation belt if launched in equatorial regions.

(4) Adaptation of the de Havilland Propellers/Rolls-Royce Blue Streak Long Range Ballistic Missile for the launching of artificial satellites heavier than the early Russian and American vehicles, using miniaturized components.

(5) Studies in the field of manned spaceflight, leading to the development of a rocket-powered skip-glider to obtain experience of manned flight on the fringe of space at hypersonic speeds. "In this country," it was emphasized, "there is already considerable experience in the development of aircraft rocket systems which, properly directed, might readily form the basis of a research programme into the problems of manned spaceflight. . . ."

The B.I.S. statement stressed that the Blue Streak could become an excellent launcher for artificial satellites and space probes, given the necessary upper staging. A great deal of money has already gone into this particular project, and, from every point of view, there would be much satisfaction if it could serve the double rôle of ballistic missile and satellite launcher.

Unofficial estimates have spoken of this particular rocket putting up a satellite of about a ton, when suitably mated with a second stage, which places its utility far above that of pure research. Such a "platform" could see the beginnings of practical experiments in radio and TV communications, weather survey, reconnaissance and even, possibly, research into the problems of re-entry. If we hope to play any part in this work a contract to develop a second stage for Blue Streak cannot be long delayed.†

Meanwhile, other avenues are opening up which show some promise for the future, if only in terms of space exploration. First, the Committee for Space Research (COSPAR), set up by the International Council of Scientific Unions, has urged that rocket facilities should be shared, which has led to the United States offering space in her own satellites for scientific research by other countries.

According to present plans within the next 12 months the United States will provide COSPAR with a complete satellite to carry 100-300 lb. of scientific instruments at heights of 1,000 to 2,000 miles. Participants in the programme will either send their equipment to the United States for installation in the satellite, or take up temporary fellowships in that country and do the work themselves.

Thus, quite soon, British-built instruments may be in orbit around the Earth. And no doubt an extension of this arrangement will later be made to include lunar and solar probes.

Valuable as these facilities undoubtedly will be, they will not provide the experience we must have if Britain is to play a progressive part in astronautical development.

Another avenue that bears investigation is the solid-propellent rocket which shows promise of reducing the cost of launching small research satellites. Scout, a four-stage all-solid satellite launcher for projecting 150-lb. payloads into 300-mile orbits, is an American project which might be studied with advantage.

Clear opportunities exist here for the joint company recently formed by Aerojet-General Corporation of America and our own Bristol Aeroplane Company. The existing factory at Banwell, near Weston-super-Mare, will eventually be supplemented by new premises in the West Country or in Wales and will be devoted to the development, manufacture, casting and testing of solid rocket motors, including propellent formulation.

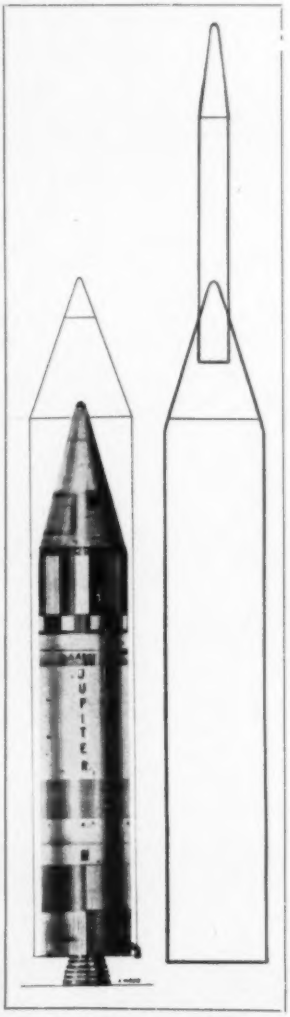
Under the joint agreement, Bristol-Aerojet, Ltd., will have the exclusive right to exploit Aerojet solid-propellent products within the field of agreement in the U.K. and the British Commonwealth. Aerojet-General, now the leading U.S. manufacturer of solid-propellent rockets, is contributing to such major projects as Polaris and Minuteman and is also supplying the initial boost stage for the Scout satellite launcher.

Finally, there is the prospect of joining with other nations interested in space research. During the past 12 months, the British Interplanetary Society has been studying the possibilities of a joint programme embracing the Commonwealth as a whole. The arguments for this stem from the steadily mounting cost of space research, which inevitably must mushroom still further when present robot experiments give way to projects for manned spaceflight. If Britain, Australia and Canada were to collaborate—sharing costs and facilities—we would have the nucleus of a Commonwealth Space Programme which would have every prospect of making a really worth-while contribution alongside Russia and America. Indeed, to the extent that the Australians have helped to finance Woomera, we already have the basis of Commonwealth co-operation.

However, in no sense does the Society see the Commonwealth as the third contender in a space race. "We must seek areas of research which we are best equipped to pursue and which, as far as possible, do not duplicate work already being done elsewhere," the group says. "Co-operation with other space-active nations should not be discouraged."

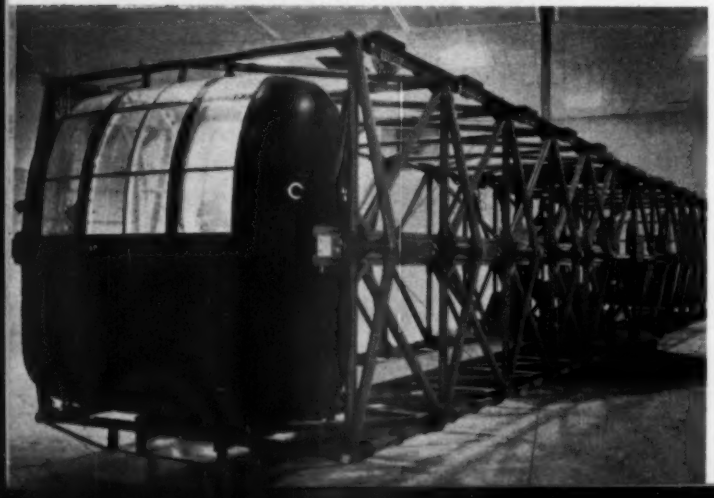
At the 9th Congress of the International Astronautical Federation in Amsterdam last year, representatives of the United Kingdom, Canada, the Union of South Africa, and India, met informally to discuss the possibility of holding a Commonwealth Spaceflight Symposium. This meeting, sponsored by the British Interplanetary Society, will be held at Church House, Westminster, on August 27-28 and will include speakers from the missile industry and other related fields of science and technology. Topics will include prospective research activities, facilities, launching sites, adaptation of existing rocket vehicles, administrative problems, economics, rôle of the universities, etc.

Without being in any way pretentious in its ambitions, this gathering should provide a useful opportunity for the many people who have expressed enthusiasm for a British or Commonwealth Space Programme to exchange ideas, and perhaps offer some solution to our Space-Age dilemma.



The relative proportions of Blue Streak, Jupiter and a Blue Streak with Black Knight second stage.

† Black Knight, having the advantage of availability, might conceivably be used as a second stage to get a programme started, but obviously would be inadequate to obtain the full potential from a Blue Streak launching system.



A piece of equipment at the Institute of Aviation Medicine at Farnborough which provides invaluable aero-medical data on high-g effects is this large man-carrying centrifuge.

Missiles and Astronautics . . . .

A Year and a Half of the Space Age

By James Strong, B.Sc., A.C.G.I., A.F.R.Ae.S.

AFTER eighteen months of the so-called Space Age, most people by now have lost count of the number of satellites hurled into space, and few could say with any certainty how many are still circling the Earth. Not that the number is itself any criterion of Man's progress towards spaceflight, for the fact is that satellite launchings have become so commonplace that only the outstanding merit front-page attention for more than a day.

To keep the records straight; there have been 24 attempts to launch a satellite or lunar probe, of which 12 were successful. There are five satellites at present in orbit, one now given up as "lost," not counting one or two final-stage rocket casings that may still be floating around. Two lunar probes are also orbiting the Sun and unlikely to return close enough to the Earth to be detected for another five years.

This list does not include any failures the U.S.S.R. may have had, for the simple reason that they do not admit to any. However, by the law of averages, including the accepted fact that missiles are notoriously unreliable, the Soviet tally of four launchings/four successes, is too good to be true. The Americans have some reason to believe that some four to six undisclosed attempts by the Russians proved abortive.

From a strictly scientific viewpoint the results contributed by the smaller, more sophisticated, U.S. satellites have been of greater value to the World. The Soviet satellites have been spectacular for their immense weight and size, but reticence on the part of the Soviet scientists to disclose the dimensions of some of the objects they have sent aloft must qualify data deduced by direct observation of their movements.

Nevertheless, the Soviet Union has gained great prestige by being the first not only to launch a satellite into orbit round the Earth, but also to send up a very successful lunar probe. It now remains to be seen whether they will complete the hat trick by being the first to "probe" a distant planet.

Sputniks I, II and III

Taking first of all the Soviet effort, which has demonstrated such astonishing capability, it is clear that the Russians have in their possession a launching vehicle of great lifting potential. There has been some suggestion of late that the Russians now realize that as a war weapon their ballistic missile is too big, and that economically they are embarrassed by its voracious thirst for fuel.

This may be true, but it has no bearing on the present situation. As launchers of orbital heavyweights they have no peer. Already they could launch a manned re-entry capsule, whereas the United States Project Mercury (Man-in-Space) is not scheduled for another three years at least. Without question, the Russians have the edge in space vehicles, and they are not likely to relinquish their lead.

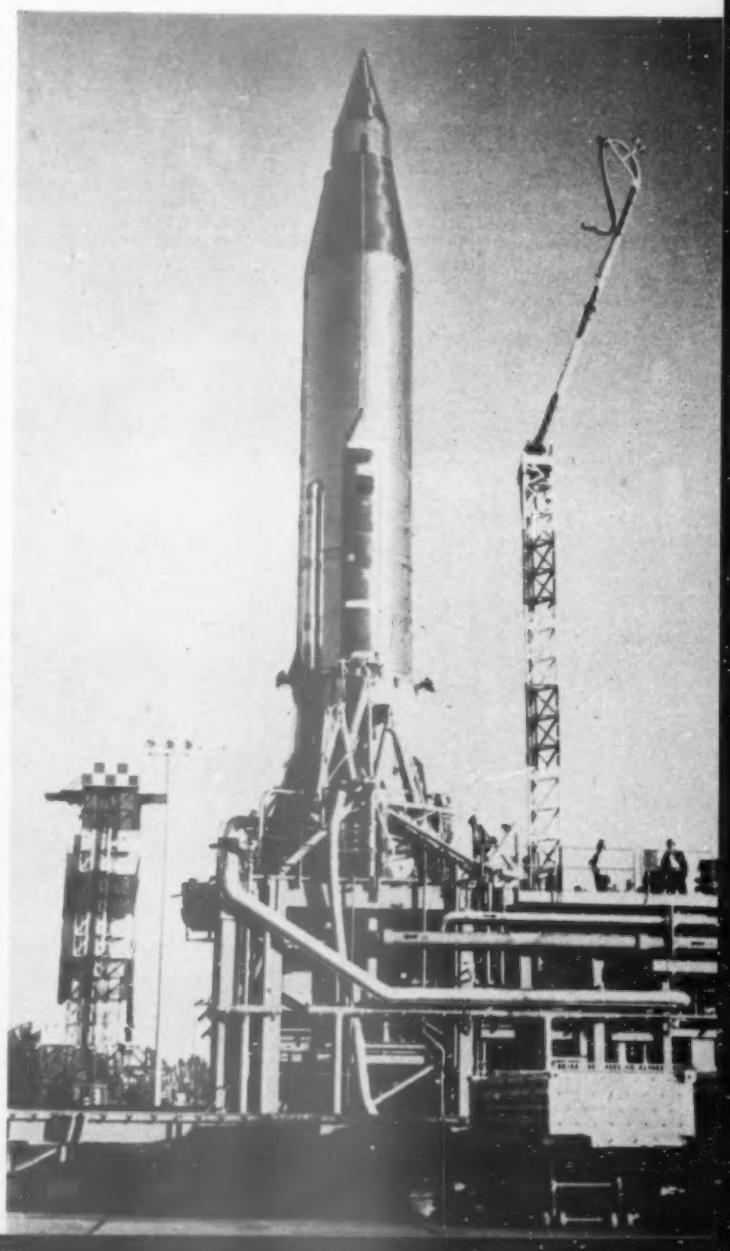
There must have been jubilation in the Kremlin when Sputnik I, the first artificial satellite, vaulted successful into orbit on the night of October 4, 1957. The fact that it weighed 184 lb. staggered a World, conditioned by publicity into thinking that the 21-lb. earth-bound Vanguard satellite would be a resounding technical achievement.

Scarcely had everyone recovered when, a month later, Sputnik II, weighing half a ton and containing a live dog, jolted them into realizing that the Space Age had arrived. The ignoble failure of the first Vanguard shortly afterwards, in a welter of limelight and flame, stung the United States into determined action.

The Russians were, however, content after that to sit back and watch the hurry and scurry they had produced in their rivals for space. It was not until May the following year (1958) that they brought out their third ace. Then they hoisted nearly a ton and half of Sputnik III into orbit. And Sputnik III had everything; it was a veritable spaceship.

The Jovian Explorers

Meanwhile, the Americans, smarting under the indignities heaped on them by Soviet success and their own failures, set about the herculean task of overtaking their rivals. The Vanguard vehicle, on which hopes had been centred, seemed too unreliable, and they decided to resurrect plans projected earlier



The U.S.A.F. Atlas B on the launching pad at Cape Canaveral prior to being used to put into orbit the 4-ton satellite to and from which messages were transmitted last December.

Missiles and Astronautics . . . .

TABLE I. EARTH SATELLITES

	Launching date	Weight (lb.)	Orbital inclination	Perigee (miles)	Apogee (miles)	Notes
Sputnik I	Oct. 4, '57	184	65°	145	560	Life 57 days. Disintegrated gradually Jan. 2–10, 1958.
Sputnik II	Nov. 3, '57	1,120	65.3°	140	1,017	Dog-carrying satellite. Re-entered April 13–14 over Caribbean.
Vanguard	Dec. 6, '57	—	—	—	—	Exploded on launching pad.
Explorer I	Jan. 31, '58	31	33.2°	229	1,578	Launched by Jupiter-C. 1st U.S. Satellite successful.
Vanguard	Feb. 5, '58	—	—	—	—	Broke up at 20,000 ft.
Explorer II	Mar. 5, '58	—	—	—	—	Final stage ignition failure.
Vanguard I	Mar. 17, '58	3¼	34.3°	403	2,463	The " Grapefruit " satellite, 6 in. diameter. Estimated life 200 years.
Explorer III	Mar. 26, '58	31	33.3°	117	1,740	Life 93 days. Fell June 27, 1958.
Vanguard	April 28, '58	—	—	—	—	Failed to orbit.
Sputnik III	May 15, '58	2,925	65°	123	1,154	Still in orbit. Life of 124 years predicted. Payload 2,133 lb.
Vanguard	May 28, '58	—	—	—	—	Failed to orbit.
Explorer IV	July 26, '58	38	50°	163	1,373	Still in orbit. Life 1.4 years.
Explorer V	Aug. 24, '58	—	—	—	—	Launch failure—collided with 1st stage on separating.
Vanguard	Sept. 26, '58	22	—	—	—	Failed to orbit.
Explorer VI	Oct. 23, '58	—	51°	—	—	Failed to orbit. Was intended to inflate 12-ft. diameter balloon in orbit.
Atlas B	Dec. 6, '58	8,750	33°	118	911	Launching weight 122 tons. Picked up and played back messages.
Vanguard II	Feb. 17, '59	21	33°	335	2,050	" Weather-eye " satellite. Still in orbit.
Discoverer I	Feb. 28, '59	40	Polar	—	—	Believed in orbit but temporarily " lost."

for a satellite launcher based on the well-tried and proven Redstone missile.

On January 31, 1958, nearly four months after Russia had inaugurated the space race, there rose from its launching pad on Cape Canaveral, America's first satellite, Explorer I. Compared to the Sputniks, Explorer's weight of 31 lb. (including the burnt-out rocket casing) was insignificant. But its 11 lb. of instruments performed well, and the satellite had gone into a higher orbit than the Soviet satellites.

This high orbiting of all U.S. satellites is a feature that tends to be overlooked. Whereas Sputniks II and III just topped 1,100 miles during their initial apogee, the U.S. satellites consistently ranged outwards to twice the distance and were therefore responsible for detecting the mysterious Van Allen radiation belts that the Sputniks missed.

As is well known now, the Explorer series of satellites were all launched from four-stage vehicles, the first stage of which consisted of a modified and lengthened Redstone vehicle designated Jupiter-C. The three stages that followed were clustered solid-propellent rockets, the fourth stage being headed by the satellite itself.

Explorer I was followed by Explorers III and IV specially instrumented to pick up the peculiar radiation that had swamped the instruments of the first Explorer. Explorers II, V and VI (which carried a large inflatable balloon) all failed to orbit for one reason or another, but the data that poured back from the others will take years to analyse completely.

TABLE II. LUNAR PROBES

	Launching Date	Notes
USAF lunar probe	Aug. 17, '58	Blew up after 77 seconds.
Pioneer I	Oct. 11 ,,	Thor IRBM. Reached 71,300 miles.
Pioneer II	Nov. 8 ,,	Destroyed shortly after launch.
Pioneer III	Dec. 7 ,,	Juno II vehicle. Reached 66,654 miles.
USSR Lunik	Jan. 2 '59	Passed within 4,660 miles ahead of Moon. Now in orbit round sun.
Pioneer IV	Mar. 9 ,,	Passed within 38,000 miles of Moon. Now in orbit round sun.

Lunik (or Mechta) weighed 3,245 lb. Has attained a perihelion of 91.5 million miles and aphelion of 123.2 million miles. Its period is 447 days.
Pioneer IV (weight 13 lb.) Perihelion 91.7 million miles, aphelion 105.8 million miles. Period 392 days.

By this time the United States was beginning to get into stride, and satellites were being launched—not always successfully—on an average once a month. Ill-luck still dogged the Vanguards, and except for the diminutive " grapefruit " satellite (the smallest object with the highest orbit) it was not until February, 1959, that the full-sized 20-inch, 21-lb. Vanguard sphere went into correct orbit.

This satellite is of considerable interest for it is the first " weather-eye " reconnaissance satellite and probably the forerunner of many more. Its two photo-cells scan the cloud cover below as the satellite rotates; and the average contrast of a sweep is recorded on a tape and played back to a ground station whenever possible.

Space Research

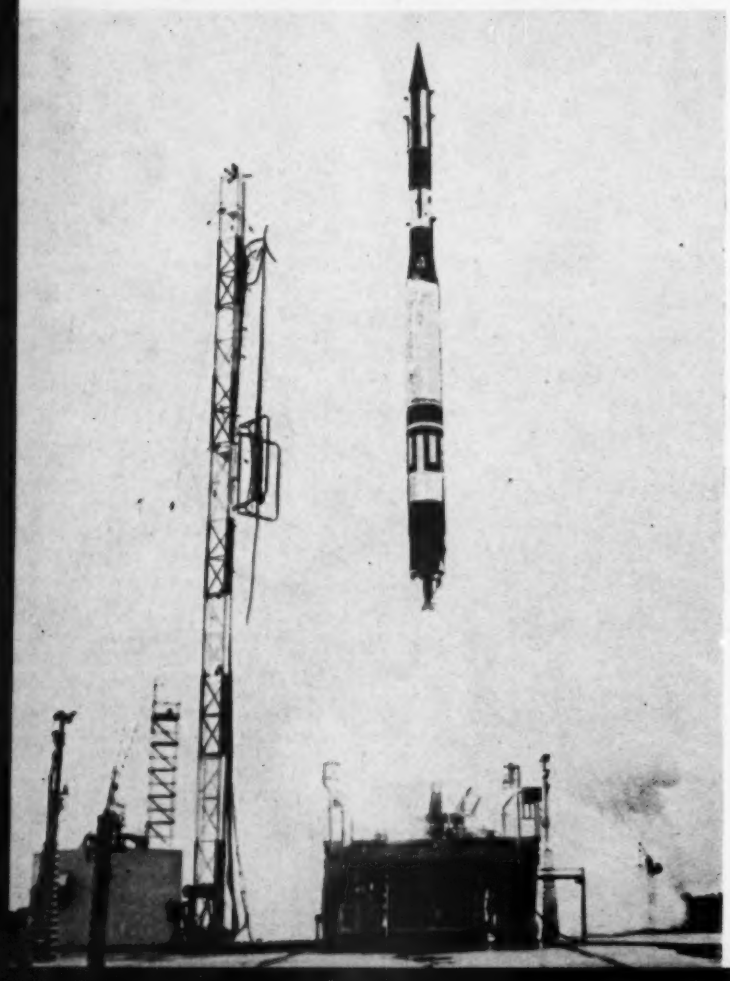
Naturally, one of the things people will want to know is whether we have profited at all by launching artificial satellites, the total cost of which must already be astronomical. The ordinary man-in-the-street, reading that they have proved the Poles to be 160 yards closer together than estimated, may feel like scoffing. But it is a fact that only with the aid of satellites have scientists been able to build up slowly and painstakingly a truer picture of conditions in space—knowledge that is vital to the future survival of man when he enters its domain.

The picture now emerging is in some ways entirely different from what had previously been imagined. Inevitably, each piece of information gained tends to touch off a multitude of fresh questions.

For example, it is now known that the atmospheric density at altitudes up to 300-400 miles, rarefied though it is, is much denser than had been anticipated. Drag estimates for re-entry capsules would have been that much in error had we not known this, a feature that could easily have meant the difference between life and death.

Another thing that has been discovered—due to seemingly minor irregularities in satellite periods—is that the global atmosphere is not only more extensive than thought, but that it

(*Continued on page 461*)



Vanguard II—a " weather-eye " satellite still in orbit—is sent on its way from Cape Canaveral on February 17, 1959

Men of Skill and Experience

NAI YOD CHAI IMM

Shell Senior Fuelling Operator
at Don Muang Airport,
Bangkok, Thailand.

SHELL

ONE OF THE MEN RESPONSIBLE FOR SHELL WORLD-WIDE AVIATION SERVICE

All turboprop-powered aircraft in Fleet operation with the Royal Navy are fitted with Rotol propellers and gearboxes

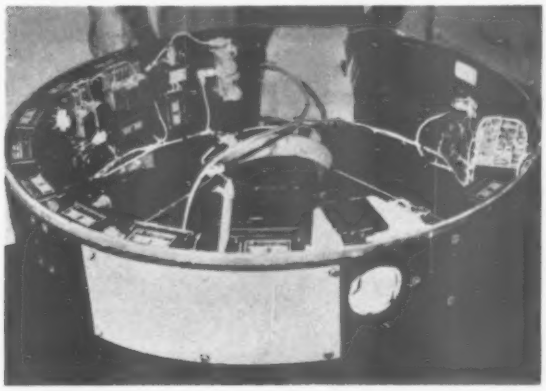
Missiles and Astronautics . . . .

TABLE III. TENTATIVE UNITED STATES LAUNCHING PROGRAMME, 1959

	Vehicle	Date	Payload	Destination	Notes
Earth Satellite ..	Able III	mid-April, 1959	325 lb.	High Orbit 500–30,000 mls.	Objective is a " stationary " orbit with a 24-hour period.
Venus Probe ..	Able IV 3-stage Thor	June 3, 1959	78 lb.	Vicinity of Planet Venus	Time to reach Venus 150 days. Vernier rockets will be fired remotely to adjust speed after 60 days. Jodrell Bank will assist with tracking from 60th day.
Venus Satellite ..	Able IV 3-stage Atlas	June 4, 1959	325 lb.	Circum-Venus Orbit	Retro-rocket fitted to payload for added thrust to put payload into orbit around Venus. Payload otherwise similar to Venus probe. Pop-out cruciform-pattern solar cells will provide electrical power.
Earth Satellites ..	Vanguard III, IV and V	—	50 lb. 21 lb. 21 lb.		Instrumentation to measure solar radiation ultra-violet and X-ray. Also magnetometer. Proton precession magnetometer only. Radiation equipment only.
Earth Satellites ..	Discoverer II, III, etc.	—	—	—	Recoverable satellites planned. Later bio-medical experiments to seek data on environmental conditions. This information needed for " Man-in-Space " project and Dyna-Soar orbital bomber.
Lunar Satellite ..	—	August, 1959	—	Orbit round the Moon	Similar venture to Pioneer I Lunar probe launched Oct. 11 last year using Thor IRBM.

(*Continued from page 460*)

undergoes rhythmic pulsations. Not only does this pulsing increase with height, but it seems to be linked closely with the Sun's rotation (27 days) and therefore associated with the passage across the Sun's disc of sunspots, which are known to be sources of high-energy radiation. This is a unique discovery for it had to be sorted out from superimposed variations in satellite period due to diurnal variations (between the day and night hemispheres of the Earth with altered density) and the additional bulging of the atmosphere at the equator.



The instrument bay for the U.S.A.F. Pioneer Moon-probe vehicle.

Who cares whether the Earth is not an oblate spheroid but more pear-shaped, and broader towards the Antarctic? Probably not many people, but it leads to the inference that the molten material beneath the Earth's crust is less elastic than had been supposed. Vanguard I, the " grapefruit " satellite, told us this.

But by far the most important discovery made by satellites is the proven existence of two concentric doughnut-shaped shells of radiation surrounding the Earth, hitherto quite unsuspected. These shells, or belts of intense radiation, are now called after Professor Van Allen, who organized the scientific instrumentation of the U.S. satellites.

The first shell extends from 1,400 to 3,400 miles from the Earth's surface; the second from 8,000 to 12,000 miles. Both have a maximum thickness in equatorial latitudes, tapering off to much less in Polar regions.

This phenomena, first detected by Explorer I, has given rise to some alarm as to whether this high-intensity radiation imposes a dangerous hazard to spaceflight. Opinion now is that when shooting through at right-angles to the belt the effects will not be significant, but that an orbiting capsule, unlucky enough to remain immersed in the belt for long periods, could possibly build up a lethal dosage.

An attempt was made to study the belts last September by detonating at the correct altitude three atomic warheads in the kiloton range. Project Argus was put into operation by launching rockets from the U.S.S. " Norton Sound," stationed for that purpose in the South Atlantic. They were timed to explode precisely as Explorer IV entered the belt north of the equator.

It was recently announced that the object of this experiment was to release, at a known time and position, a known quantity of electrons having known energies. The full results have yet to be published, but it has been reported that the project was most successful in confirming theory.

The Lunar Probes

Within the past six months events have dramatically reshaped the World's outlook to space flight. From merely coasting in circles beyond the terrestial atmosphere, satellites have begun to penetrate cislunar space (i.e., the region between Earth and the Moon), and it is evident that a grim race for the Moon is now on. Who is going to claim ownership of that pitted and sterile piece of real estate is one of those awkward questions that will be put on the United Nations' plate within the next year or two.

The Americans were the first to make a bid for the Moon by attempting to launch a circum-lunar probe in August, 1958. This attempt ended disastrously shortly after take-off, and it was not until October that a Thor IRBM, allied to a Vanguard second-stage and a third-stage solid rocket, succeeded in pushing a small probe out to a distance of 71,300 miles from the Earth. The following month a second abortive attempt followed, and when, in December, the U.S. Army's four-stage Juno II only reached 66,650 miles out it looked as if the task was just beyond the reach of present-day missiles.

For reasons best known to themselves, the Russians, up till then, had displayed no interest whatever in Moon-shot projects, though there were rumours that they had made one attempt

TABLE IV. PROJECTS OF THE FUTURE

Project Saturn .. .. (formerly Juno V)	Cluster of eight 150,000-lb. thrust North American Rocketdyne motors forming 1st stage. 2nd stage Centaur (if ready), otherwise Atlas, Titan or Minuteman. 35,000 lb. payload in 300-mile orbit round the Earth. Flight test planned for autumn, 1960. Test rigs for cluster in preparation.
Mrs. V. .. .. (Manœuvreable recoverable space vehicle)	A requirement for space vehicles to manœuvre in and out of orbit and develop spaceflight performance similar to that enjoyed by manned aircraft in the atmosphere. Preliminary objectives to be achieved within the next 5–10 years.
Centaur	High-energy upper stage being developed by Convair Div. of General Dynamic Corp. and Pratt & Whitney Div. of United Aircraft Corp. First attempt to design a liquid hydrogen/liquid oxygen motor.
Project Mercury .. .. (Man-in-Space)	Manned Capsule to be projected into near-circular orbit of 100–150 miles for 24 hours. Afterwards re-entry and recovery by means of retarding rockets.
" Man-on-the-Moon "	Cluster of six 1,000,000-lb. single-chamber motors developed by North American Aviation. Five-stage vehicle. Aim is to put a 200,000-lb. payload into a 300-mile orbit. Later a cluster of 12 motors will double this load or, with nuclear-powered upper stage, make a " soft " landing on Moon or transport 55,000 lb. to Mars. Date for initial project—1966.
Vega	Atlas with General Electric 1st-stage Vanguard (X–405x on top). Later a 6,000-lb. solid motor as 3rd stage. Payload 7,500 lb. in 300 mile orbit, or 1,000 lb. to escape velocity.

Missiles and Astronautics . . . .

earlier in the year but without success. The World was therefore taken by surprise when, on January, 1959, they announced that at that moment a 3,240-lb. lunar probe was on its way. They predicted that it would pass within 5,000 miles of the Moon, slightly ahead, before going into an elliptical orbit round the Sun.

Despite the fact that the only corroboration of Lunik's flight were a few spasmodic telemetry transmissions, there now seems no doubt that the probe performed as the Soviet authorities had predicted. It was timed to release a quantity of sodium vapour when 75,000 miles from the Earth, and the resulting cloud of luminescence was seen to appear in the right quarter at the right time.

Somewhat ruffled by the news that what they couldn't do the Soviet Union could do better, the United States missile teams redoubled their efforts. On March 3 they successfully launched Pioneer IV, a tiny gold-plated conical probe, weighing 13 lb., that missed the Moon by 37,300 miles and then continued onwards into a solar orbit.

It is no secret that the Soviet Union had hoped to impact the Moon, whereas the U.S. probes were primarily intended to orbit the Moon and scan its surface with an infra-red device. In the latest U.S. programme, future lunar probes seem to have lost all priority which, if it is true, will be a pity. The first nation to contact the Moon will have a strong case for priority of possession in the legal squabbles that are sure to follow. Both sides probably realize, however, that "first come—first served" is the unwritten law of exploration and conquest.

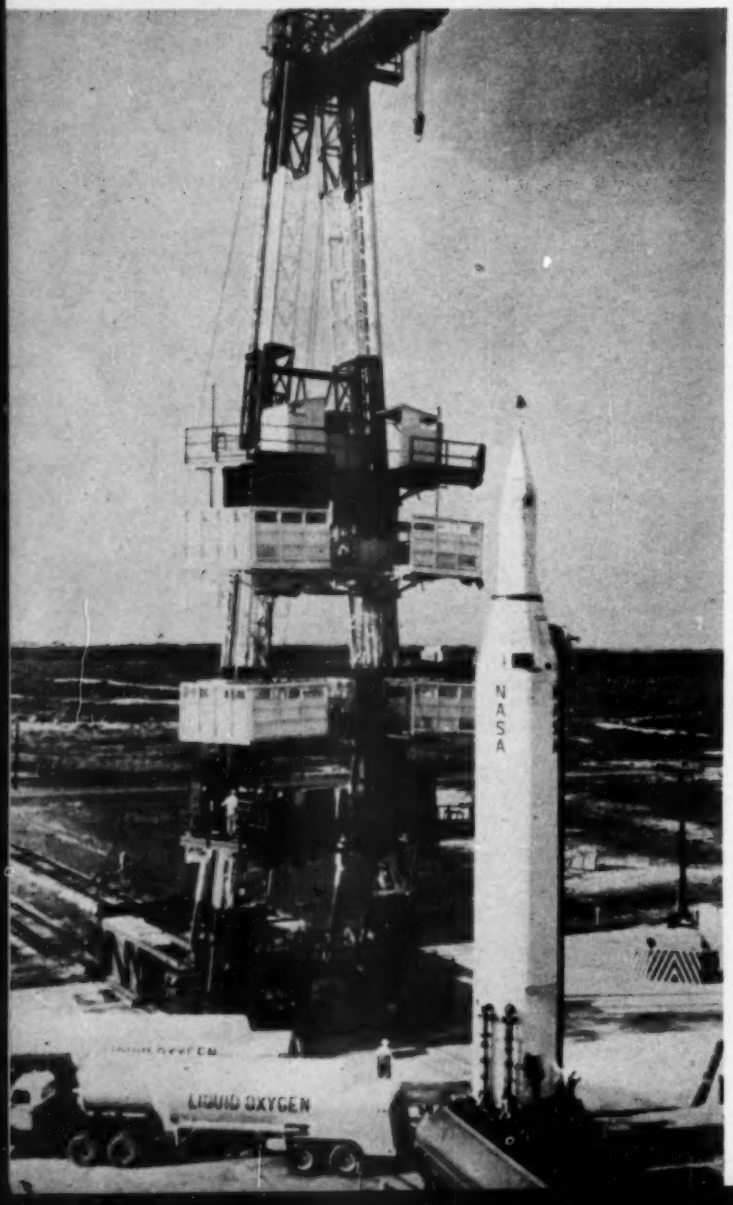
Interplanetary Probes and the Future

Early in June, the United States hopes to dispatch two instrumented probes in the direction of the planet Venus, whose orbit lies closer to the Sun by some 30 million miles. And, as Venus will not approach closely again until January, 1961, it is more than likely that the Soviet Union will also try to launch a probe before the month is out.

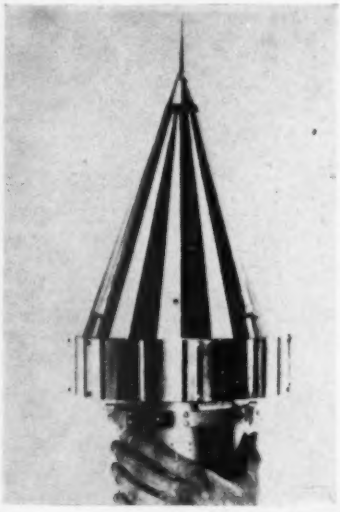
The Americans plan to fire first a three-stage Thor-Able rocket on June 3, following it the next day with an Atlas-Able three-stager carrying a 325-lb. probe and retro-rocket. Both probes will have vernier rockets for speed adjustment later in the journey, but the second probe will attempt to slow and go into a permanent orbit round Venus. Its subsequent entry of the Venusian atmosphere will be watched with considerable interest.

This project is one of the most ambitious ever planned, and is fenced with difficulties. The probes should take 150 days to reach the vicinity of Venus, and the behaviour of the leading probe will be carefully watched so that corrections to the flight path of the second can be made properly. The planet's orbit and position is, even now, not known to within an accuracy of several thousand miles.

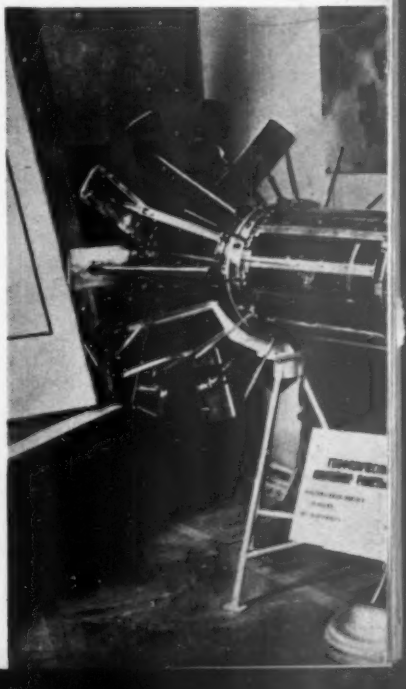
Both probes will be fitted with batteries of solar cells that unfold into a cruciform pattern once the probe is in free flight. These cells will power the radio transmitters with which it is hoped to follow their flight. From the 60th day onwards the U.S. will have to rely entirely on Jodrell Bank to keep track, for by then the probes will be 10-15 million miles away. When



Left, some idea of the relative sizes of vehicle and "payload" for a typical Moon-probe rocket is given by this photograph of an American four-stage Juno II on the launching pad and (above) the close-up of its conical "probe."

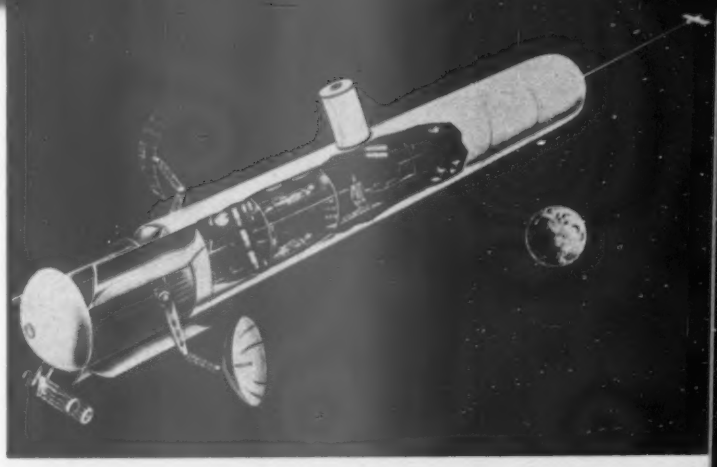


Right, an instrument container from a Russian meteorological sounding rocket which is said to have been lowered by parachute from a height of nearly 70 miles. Note airbrakes presumably for speed reduction prior to parachute deployment.



Right, the instrument-container portion of a Russian A2 I.G.Y. rocket which reached an altitude of 130 miles. This container is said to weigh 800 lb.

Right, a North American Rocketdyne artist's impression of a manned space station; it is 7 ft. in diameter and 35 ft. long.

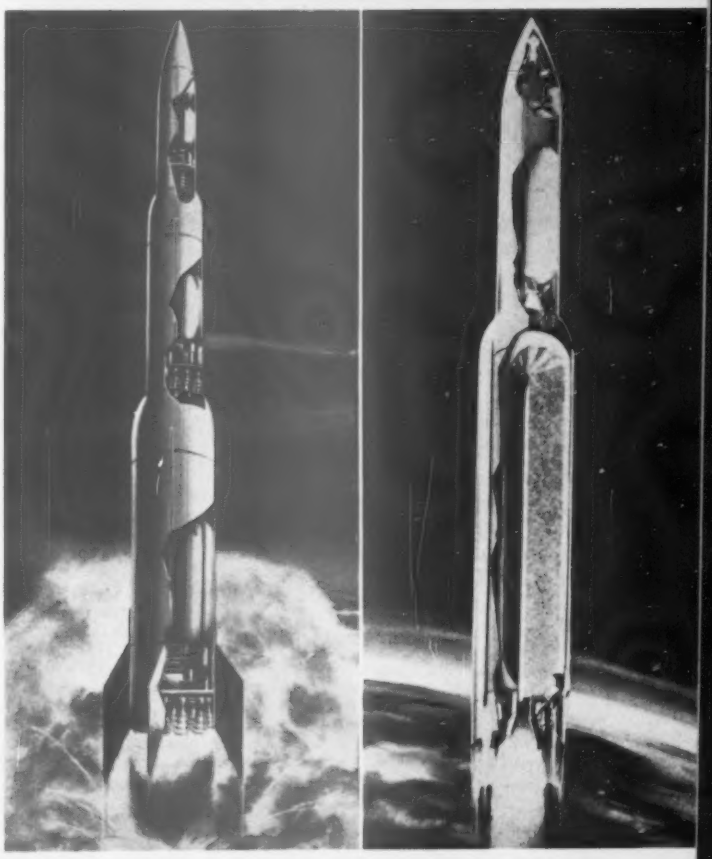


the moment arrives to fire the retro-rocket by remote control, allowance must be made for the time the command signal takes to cross space, a matter of several minutes.

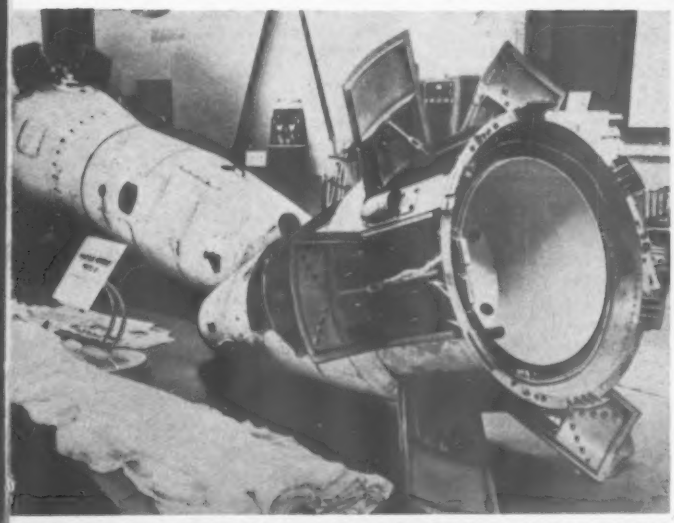
But though the Venus probes, the Vanguards and the Discoverer satellites scheduled for firing this year are highlights in a year that promises plenty of interest, these projects all make use of existing hardware. It is the proposals recently placed before the U.S. Congress by ARPA and NASA that really point the way to a fantastic future in space. Their aim is clear—true spaceflight within a decade, and no one need any longer be ashamed to use that hitherto disreputable word, spaceship. The United States is going to build them.

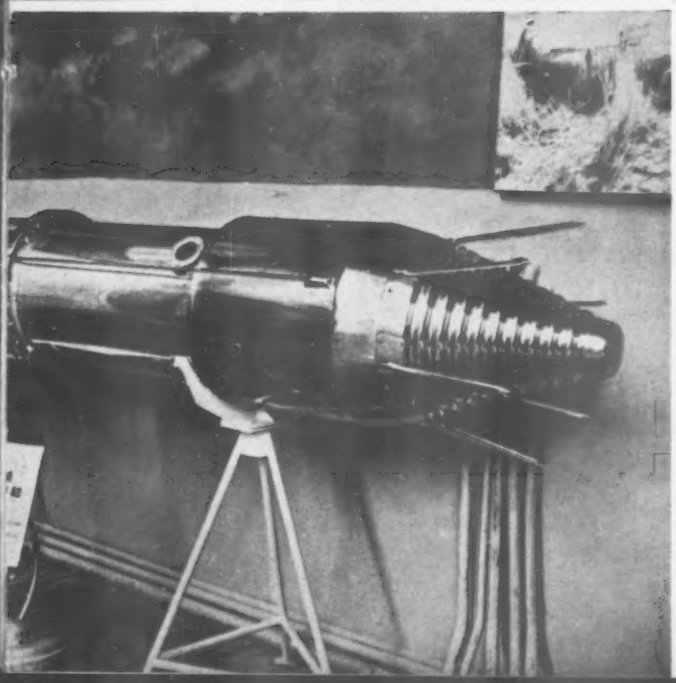
There are two outstanding projects in the American scheme of things that promise high adventure beyond the ionosphere. The first is Project Saturn, a proposal to cluster eight 150,000-lb.-thrust Rocketdyne motors to form a first-stage vehicle with a useful thrust of more than a million pounds. The second stage may be an Atlas, or some equally powerful alternative. The payload to be put into a 300-mile orbit is no less than 15 tons.

The second scheme, Project Mercury, is a carefuly studied design for a manned, recoverable capsule that will circle the Earth for 24 hours in low orbit (100-150 miles) and then be slowed by retarding rockets to a safe re-entry speed. Contracts for the capsule design have now been placed, and after several instrument-controlled flights have shown no defect in the



Above, other Rocketdyne artists' impressions are of (left) a three-stage rocket intended for reaching Mars and Venus and (right) a two-stage solid propellent unit carrying in its nose a "long-duration low-power" vehicle for solar system reconnaissance.





design, a volunteer will be chosen to take the first ride in space. It is probable that the launching vehicle will be a boosted-up Atlas, and Project Mercury is scheduled to take place in about three years time.

Parallel with the development of the clustered power unit, orders have now been placed for the design of a single-chambered, million-pound-thrust motor. This enormous motor, which some have estimated to be 19 ft. long, with a 10-ft. diameter venturi, must be ready and fully proved, in five years time.

Furthermore, a proposal has now been made to cluster six of these huge units so as to place 200,000 lb. of payload into orbit two years later. Should this prove successful, 12 of them may be clustered to form the first stage for a nuclear-powered rocket that could carry a crew to the Moon, make a "soft" landing and return. To the Moon and back by 1966 would appear to be America's aim—always assuming the Russians have not already done it.

Missiles and Astronautics . . . .

Britain's Rocket Propulsion Establishment

By J. E. P. Dunning, M.A., F.R.Ae.S.*

A MINISTRY of Supply Establishment has existed at Westcott, near Aylesbury, since 1946, when the Guided Projectile Establishment was set up. Since that date it has undergone many titular vicissitudes; but apart from the brief initial phase, its main purpose has been to further the research and development on rocket propulsion and to study the problems arising from the application of rockets.

For the greater part of its existence, the Establishment was an outstation of the Royal Aircraft Establishment. On August 1, 1958, however, it became the Rocket Propulsion Establishment answering directly to the Controller of Guided Weapons and Electronics. Its penultimate title was "R.A.E., Westcott" and there is no doubt that "Westcott" will persist as the popular designation.

The severance of the administrative links with Farnborough has in no way impaired the scientific and technical collaboration with the R.A.E. The Ministry of Supply is composed of many "R and D" establishments, some small, some large—each responsible for the advancement in one or more fields of applied science—with the overall control of policy and administration resting in London.

It is understandable that many of the establishments have overlapping interests and these should be regarded as a source of strength. These scientific and technical cross links from one establishment to another provide supports to the radial links from London. If the structural simile is extended, one may liken the Ministry of Supply to a lattice structure with adequate stiffness and little, if any, redundancy.

Extending this simile still further, each individual establishment must be regarded as a pin joint, the position and function of which are vitally dependent on the positions and functions of sister establishments. Thus when we consider Westcott, it cannot be studied in isolation, but rather as a component of the Ministry of Supply complex.

Co-ordinating Links

Under this heading I should like first to mention the Explosives Research and Development Establishment at Waltham Abbey, Essex. This establishment (E.R.D.E.) has an important rôle, complementary to that of Westcott, in that it provides the chemical formulations of the propellents we use.

Emphasis in the E.R.D.E. support to us lies in the solid propellent field. The emphasis is there simply because solid propellents are complex chemical compositions and liquid propellents are generally single substances, accepted either as an oxidant or a fuel because of their intrinsic physical and chemical characteristics.

The location of E.R.D.E. at Waltham Abbey has much greater historical significance than has the siting of R.P.E. at Westcott. It was within the Abbey precincts that gunpowder was first made in this country and from these monastic beginnings the Royal Gunpowder Factory emerged.

It is probably true to say that ever since explosives have had a reckonable military value, their manufacture has been the prerogative of the Government and the Royal Ordnance Factories have been set up for this purpose. Solid propellents for rockets may be regarded as modified explosives and it was a logical and straightforward step to redirect effort in the R.O.F.s from shells to rockets. In this comparatively new rôle, a few of the R.O.F.s are complementary to the E.R.D.E. and to Westcott in that they produce propellents developed by E.R.D.E. and motors designed and developed by R.P.E.

In this country the development of liquid-propellent rockets is a post-War activity and, since one of the potential applications of liquid-propellent rockets was to aircraft, one can understand readily why the established aero-engine companies have undertaken their manufacture. Westcott, therefore, maintains strong technical links with these companies. Once more, the rôles are complementary; yet the pattern of collaboration is somewhat different from that on the solid-propellent side.

The engine firms maintain their own design and development teams and tender for contracts from the Ministry of Supply to meet particular operational requirements. As part of its function, Westcott will have advised the Ministry of Supply on these O.R.s and will later be called on to give an appraisal of the tenders submitted. Thus Westcott is a technical assessor of the firms' proposals and the implications of this rôle are discussed more fully later. It is sufficient now to say that close collaboration between industry and the Establishment is vital.

So far, I have mentioned those links which Westcott maintains to ensure the making of both solid-propellent and liquid-propellent rockets. Our collaboration with the R.A.E., and to a lesser extent with the Armament Research and Development Establishment (A.R.D.E.) at Fort Halstead, centres on the application of rockets.

Here, perhaps, the distinction between rockets and guided missiles, terms which are often wrongly used as synonymous, should be emphasized. A rocket is a source of thrust which, because of its inherent characteristics, is eminently suitable for guided missiles and indeed, in some cases, is the only feasible means of propulsion.

* Director, Rocket Propulsion Establishment.

A Raven solid-propellent rocket motor for the Skylark I.G.Y. meteorological sounding vehicle, being fired in the test area at R.P.E. Westcott.

I have already stated that the main purpose of Westcott is to further the research and development on rocket propulsion. This purpose exists because the rocket is a propulsion device pre-eminently suitable for guided missiles and for some types of aircraft. Furthermore, it provides the only means of obtaining thrust outside the Earth's atmosphere.

These incentives have created the post-war development programme under which a variety of solid- and liquid-propellent rockets have evolved. Most of man's inventions have been subjected to an evolutionary process in which, by trial and error, bad design features have been eliminated and good design practices established. To this the rocket has been no exception.

In the early history of an invention, *ad hoc* development is virtually the only method by which a working model can be created. The behaviour of this model may confirm the underlying principles, if such confirmation were needed, but it will certainly reveal more basic problems and perhaps indicate their relative significance. Thus the model plays an important part in formulating a research programme; and the extent to which this programme is sound will determine how quickly the problems are solved and the most profitable lines of development.

In other words, research—or, more correctly, applied research—is possible only after an initial development phase and its purpose is to minimize subsequent development by ensuring that it proceeds on sound lines. Research and development are, therefore, complementary terms and as an R and D establishment it is Westcott's duty to lay down sound design principles for rockets. Stemming from this Westcott must indicate the worthwhile developments for the future and act as advisers to and assessors for the M.o.S.

With these responsibilities, the implications are that Westcott should be in the forefront in its thinking on rocket propulsion. To this end it maintains its own creative programme and the facilities to conduct this programme.

The art of compromise is never absent from man's endeavours to improve his machines and the development of rockets demands it to a high degree. Thus at Westcott, we have the interplay of one discipline upon another and our success in the art must be judged, as with our broader responsibilities, by our past achievements.

Internal Organization

Before attempting to describe Westcott's achievements I should like to portray the "family tree," because it is this which forms the Establishment. The indications have been given that the creation of a rocket invokes many disciplines; the staff at Westcott is comprised of mathematicians, chemists, physicists, metallurgists, engineers, draughtsmen and skilled craftsmen together with personnel necessary for their welfare.

I should be most reluctant to assess the relative importance of the various skills and it would be pointless to do so. One person alone has little creative ability yet as a member of a team he, or she, may achieve much.

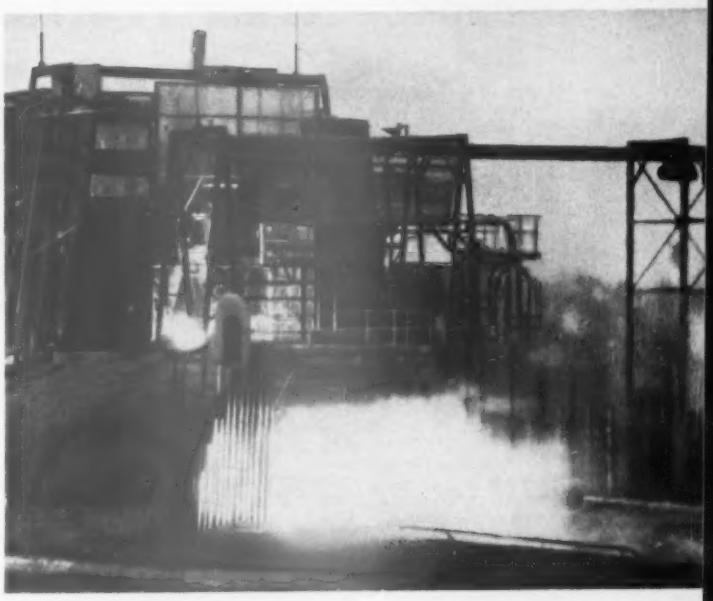
Over the past few years, the staff structure has attained some measure of stability, indicative that rocket technology is beginning to advance on well-defined paths.

The R and D work is looked after in three Divisions, whose needs are catered for by a Technical Services Section and an Engineering Services Section. The Divisions are responsible for: Combustion and Materials; Liquid Propellent Rockets; Solid Propellent Rockets. These responsibilities are clearly defined, but the Divisions have many common interests and needs, besides those coming within the purview of the Engineering and Technical Services Sections. To mention but two, there are the Library and the Instrument Research Section, the control of which is shared among Heads of Divisions.

The Technical Services Section is responsible for the design, construction and maintenance of all test facilities and equipment, and to this end calls on the services of the Ministry of Works staff permanently stationed at Westcott. It also ensures the supply of propellents and such consumable stores to the right place at the right time; meets the needs of the Establishment for standard instrumentation; and all our needs for still and ciné photography.

The Engineering Services Section comprises the drawing office and workshops and the Head of Section also has the responsibility for the training of the apprentices. The Ministry of Supply rightly attaches great importance to this latter task, which is the only way of ensuring a continuing supply of craftsmen in the future.

Already I have said that one person alone has little creative ability. Perhaps it is more correct to say that one person alone has little power to demonstrate his creative ability. In an applied research and development field in which there is a strong element of engineering, and this is certainly so with rockets, the most brilliant scientist cannot go very far without calling in the services of the draughtsman and the craftsman. They are key personnel who transform ideas into tangible tools for the service of the scientist and the engineer.



The new P.2 test site at Westcott with a firing taking place.

By their very nature, rockets introduce hazards which have to be understood before they can be mastered. As we are not infallible, mishaps are bound to occur and this fact forms the basis of our safety philosophy.

We work on possibilities, not probabilities; if a particular event is possible, no matter how improbable, we endeavour to cater for it. Thus we expect to suffer material damage, but do our utmost to protect personnel. As one example, we do not permit direct vision of a rocket under test, unless it is of a design having some past proof of reliability and then only from a distance deemed in excess of fragment throw.

Our safety record is not spotless, but the analysis of our surgery records will reveal that over 98% of the treatment is concerned with mishaps which are met with in all walks of life. If it were 100% we could justifiably claim a complete mastery of all rocket risks. This is our target and we can but strive to reach it. Without wishing to appear complacent, the fact that our safety record is good is due to the vigilance of staff who make "safety" their business.

Combustion and Materials Division

As its name implies, this Division is primarily concerned with problems of a chemical and physical nature and is not so closely bound up with project development as are the other two Divisions. On the other hand, it maintains most of our links with the research laboratories in the Universities. Even so, it has many problems of an applied or development nature and has responsibilities for the study of "dependent" phenomena, such as the attenuating and modulating effects of rocket exhaust gases on radio signals. Furthermore, it provides a specialized service to the whole establishment in the fields of analytical chemistry, metallurgy and radiographic inspection.

An early requirement was the selection of materials suitable for use with such liquids as nitric acid, hydrogen peroxide and liquid oxygen. Having in mind the chief application of rockets, the adoption of commercial techniques was not always feasible. That rockets are available nowadays which use these substances is indicative that most of the problems of compatibility have been solved.

All internal-combustion engines, with the exception of rockets, use air as the working medium. It is understandable, therefore, that, even now, most of the basic studies of combustion processes are centred on airborne oxygen. Furthermore, these processes usually occur at pressures well below those suitable for rocket chambers and the diluent effect of the airborne nitrogen has maintained a major restraint on combustion temperatures.

Thus, rocket combustion is virtually a new phenomenon and new techniques have been, and are still being, developed to study it. The mass spectrometer, the ultra-high-speed camera and the ubiquitous electronics are powerful tools without which our combustion work could not progress.

The mass spectrometer has so speeded up the analysis of samples of combustion products that results can be available

Missiles and Astronautics . . . .

within half an hour of the sampling. By normal analytical methods this process might well take several hours and was the rate-controlling factor on combustion studies.

Among the application of photographic techniques for rocket research, mention might be made here of the use of high-speed still cameras for combustion studies. Exposures of less than one microsecond duration are employed.

Rocket combustion implies very high temperatures and this in turn implies problems in materials. The most difficult material problems in a rocket are those imposed by conditions of the exhaust gas at the throat of the propelling nozzle.

These are aggravated in the case of a solid-propellent rocket because no cooling medium is used. Fortunately only one cycle of operation has to be catered for.

In a solid-propellent rocket only a few milliseconds elapse between pressing the firing button and the attainment of full thrust. The throat is therefore subjected to impact loading, thermal shock and the erosive effect of high-speed gases at high temperature. With no provision of cooling, the surface of the nozzle throat rapidly attains the temperature of the gas.

No metal will withstand such conditions and resort has to be made to ceramics, which are generally brittle and have low thermal conductivity. This latter property, or lack of it, presents something of a paradox which serves to illustrate the complexity of the problem. A perfect heat insulator would not suffer from thermal shock and neither would a perfect heat conductor. In practice, neither property is obtainable, but other considerations favour the perfect insulator and our efforts are directed accordingly.

Space precludes me from expanding on this topic, but it should be stated that although satisfactory propelling nozzles are made today, the continuous efforts to improve rocket performance means higher gas temperatures and velocities and no relaxation may be permitted in our efforts to get better materials.

With the advent of satellites, the problem of re-entry into the Earth's atmosphere has come to the fore. Because of the extremely high speeds kinetic heating is encountered and this has created problems on materials akin to those associated with the propelling nozzle. At Westcott we are actively engaged, in close co-operation with the R.A.E., on seeking solutions.

In this brief outline of the Division's activities I must conclude with a reference to the Library. It gives a service to the whole Establishment but for administration purposes is housed within the Combustion and Materials Division. In addition to its normal internal service it has national and international responsibilities in the gathering and dissemination of technical data on rockets.

Liquid Propellent Rocket Division

In giving a short review of the work of this Division it is not possible to avoid reference to the development of solid-propellent rockets in recent years, because this has had a profound influence in limiting the applications of the liquid-propellent unit. Apart from use in aircraft—and the Defence White Paper of 1957(?) reveals that this use is to be small—British development of liquid-propellent rockets is now confined to ballistic missiles.

Nevertheless, early work at Westcott gave satisfactory propulsion units to many test vehicles in the direct line of development of Seaslug and Thunderbird. The Black Knight is powered by engines manufactured by Armstrong Siddeley Motors, which are based on Gamma engines as developed at Westcott. This engine has demonstrated successfully many features which are now accepted as standard in Britain and America for all rocket engines using hydrogen peroxide.

Whereas the surface-to-air guided missiles require rockets giving thrusts of around 5,000 lb., ballistic missiles require thrusts exceeding this value by a factor of 20 or more. Furthermore, this latter application places more emphasis on high propellent specific impulse and low engine weight. Understandably there has been some reorientation of thinking and many problems, hitherto dormant, have come to the fore.

Difficulties in development always increase with increase in scale, and the larger engines now required have demonstrated the immense value of small-scale work and the necessity of having a true understanding of all the phenomena within a rocket engine. This is merely giving added emphasis to an earlier statement that a sound programme of applied research will minimize subsequent development. Full-scale development can never be done away with, however, and much effort in this Division is now in direct support of Rolls-Royce and the Blue Streak engines.

Before this support could assume a tangible form much preparatory work was essential and in particular our operating techniques had to be reviewed. The bringing into commission of the largest rocket test site in the country demanded the combined efforts of this Division, Technical Services and the Instrument Research Sections.

Our safety philosophy of catering for possibilities, no matter how improbable, has been applied rigorously. The "fail safe" devices have set a new technique in rocket testing and are enhancing the rate at which testing can proceed. This test site is designated "P.2" and the work done with it constitutes the preliminaries to the programme planned for Spadeadam.

It is designed so that the rocket engines for ballistic missiles are tested under conditions which simulate as closely as possible those pertaining to actual operation. The engine is mounted vertically in the test bay and during the firing phase, thrust, propellent flow rate and significant temperatures and pressures are measured. For these, 96 channels of electronic signals are used and one test alone may produce over 200 ft. of film record.

As witnesses of films taken at Cape Canaveral will know, the launching of a ballistic missile is a spectacular event for which most careful planning is required. At Westcott, many of the launching problems have been studied in a static system and design principles established for the Blue Streak launcher.

Now that Earth satellites have been launched and the Moon has been approached by Russian and American probes, it may be considered that the liquid-propellent rocket is nearing its ultimate phase of development. This is far from the truth. Nor has the law of diminishing returns yet begun to apply. The odds are still very much against a satellite being launched successfully and the failures are generally attributable to the rockets. Our aim is to reverse these odds and when we do we may have some justification to the claim of being rocket experts.

Solid Propellent Rocket Division

When a solid-propellent rocket works it merely gives confirmation that it is a good replica of a sound design. On the other hand, the failure of a solid-propellent rocket does not necessarily imply that the design is unsound. Rather does it indicate that it was not a true replica of a sound design.

In this observation lies the key to successful solid-propellent rocket technology. Step-by-step control and inspection of all the rocket components is vital and many modern techniques have been harnessed for this purpose. The use of X-rays, radio-isotopes and ultra-sonic sounding is now standard after much painstaking development work at E.R.D.E. and R.P.E.

Inspection by itself cannot ensure a sound design, however. This can be achieved only by much theoretical and experimental study, test firings and a careful analysis of all test results, whether they be marked by success or marred by failure. Without the acquisition of test results no analysis would be possible and the test firing would serve little purpose.

As with liquid-propellent rockets, solid-propellent units impose exacting demands on instrumentation techniques. All measurements have to be converted to electrical signals and only electronic recording is feasible. Even so, no record can be more accurate than the instrument which generates the electrical signal and at Westcott the Instrument Research Section has developed transducers for thrust and pressure measurements which not only meet our requirements, but set a standard not yet attained elsewhere.

My justification for these digressions on inspection and instrumentation is because it is the solid-propellent rocket which has set the pace in these fields. I have still to show whether the pace has been justified.

Perhaps one simple statement will suffice. All British guided missiles on which information has been released use for all or part of their flight path solid-propellent rockets which have been designed and developed at Westcott.

Nevertheless, as I said at the beginning, Westcott is only a pin joint of the Ministry of Supply structure, and can function only when given proper support. It may be surmised that this support has been forthcoming.

I have refrained from presenting a catalogue of Westcott rockets but would conclude this section by reference to one specific unit—the Raven, which is the latest type on which information has been released. The Raven is the propulsion unit for Skylark, the upper atmosphere research vehicle designed by the R.A.E. which constituted one part of Britain's contribution to the International Geophysical Year. To us, the Raven, a rocket motor of 17 in. diameter and 17 ft. in length giving a thrust approaching 10,000 lb. has been a rewarding technical development.

In the foregoing, much has been left unsaid and, perhaps, the emphasis has been on the past. It will be understandable that this should be so, but it is my hope that the past will be judged sound enough to provide an adequate basis for the future. My family motto is "Thrust On" and could anything be more appropriate for the Rocket Propulsion Establishment?

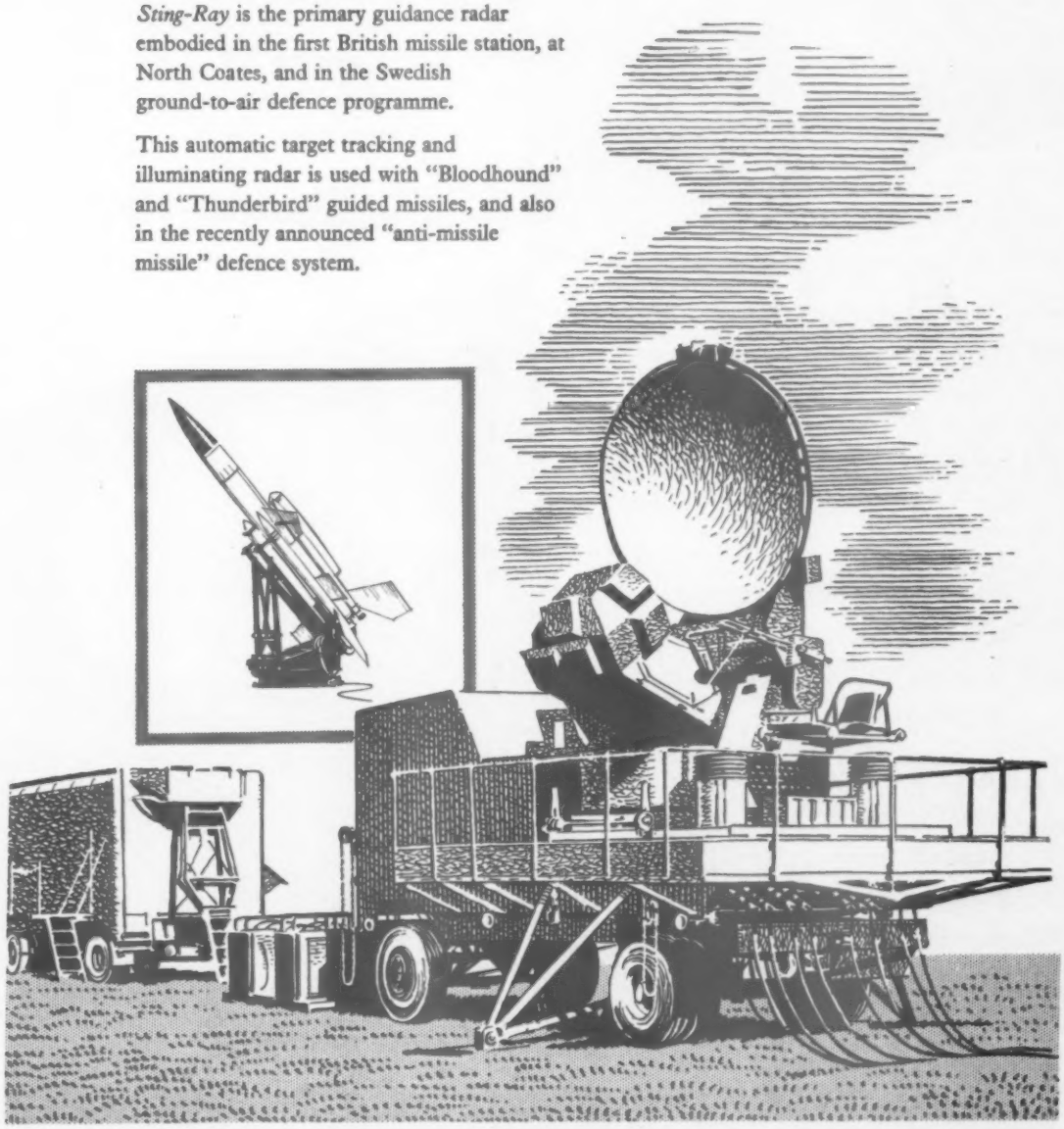
B T-H STING-RAY

TARGET TRACKING AND ILLUMINATING RADAR

for surface-to-air guided weapon systems

Developed and manufactured by BTH, *Sting-Ray* is the primary guidance radar embodied in the first British missile station, at North Coates, and in the Swedish ground-to-air defence programme.

This automatic target tracking and illuminating radar is used with "Bloodhound" and "Thunderbird" guided missiles, and also in the recently announced "anti-missile missile" defence system.



BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED · LEICESTER · ENGLAND

an A.E.I. Company

A.5335

... the missile must be recovered

IRVIN

SUPERSONIC

PARACHUTE RECOVERY SYSTEMS

The recovery of test vehicles is an essential part of the development and testing stages of guided missiles.

IRVIN-designed parachute-recovery systems have scored great successes in recent missile projects which entailed recovery of test vehicles from speeds in excess of Mach 1·5.

The Irving Airchute of Great Britain Ltd.

LETCHWORTH · HERTFORDSHIRE · ENGLAND

Telephone: Letchworth 888 Telegrams: Irvin, Letchworth

Missiles and Astronautics . . . .

Elements of Missile and Space Technology

By D. Howe, D.C.Ae., A.M.I.Mech.E., A.F.R.Ae.S., F.B.I.S.*

SPACE EXPLORATION by manned vehicles became a possibility with the advent of the German A4 (V2) rocket in the latter stages of the late War. Although a remarkable scientific and engineering achievement, the A4 was economically inefficient and was only justified by the extreme circumstances in which it was used. The main failing was the inaccuracy of its guidance system—only some 30% of attempted firings impacted within a 50-sq.-mile target area.

Post-war development of large rocket vehicles was largely intended to correct this fault, the problem being eased considerably by the advent of the atomic warhead. Although the use of rockets for atmosphere research was pioneered, these were usually comparatively small, and for some 10 or more years there was no radical increase in the size of rocket vehicles.

Paper studies of large ballistic missiles capable of intercontinental ranges were judged to be impracticable in view of the extreme size required to carry a useful payload. This picture was changed by the successful development of the hydrogen warhead, which enabled feasible long-range weapons to be conceived. The past four or five years, therefore, have seen enormous strides in rocket vehicle development.

It is of interest to note that this development was delayed until economic military application became possible. Scientific applications were not overlooked but, in the Western World at least, given Cinderella treatment. The Vanguard satellite launching vehicle has not proved to be very successful in the light of events which have overtaken it, but it must be remembered that it was designed as the cheapest and smallest unit which could be conceived to do the job. This situation only changed when the Soviet Union successfully launched Sputnik I, using adapted ballistic missile hardware, and the political prestige value of upper atmosphere and space exploration became apparent.

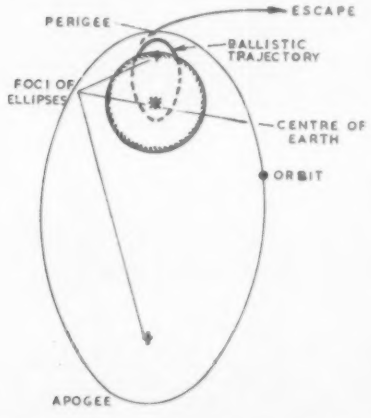


Fig. 1. Types of trajectory.

As recorded elsewhere in this issue, the 18 months since this historic event sparked off the "space race" have seen spectacular developments in space technology—Earth satellites are becoming commonplace and the first vehicles to escape from the Earth's gravity field have been fired. The time when man himself will venture into outer space has been brought nearer by the placing of contracts in connection with the U.S. project "Mercury."

The cost is enormous, the NASA having budgeted to spend the equivalent of £25 million on manned spaceflight developments during 1960, the total "space" expenditure being about £118 million. Much of the present space research uses hardware developed for ballistic missiles, but before real progress can be made a further stage of development must be undertaken.

The dispatch of rocket vehicles to the planets is just a matter of time, but it must not be forgotten that to date no satellite or space vehicle has been successfully recovered on re-entry to the Earth. Much has yet to be accomplished before true spaceflight becomes a possibility—much more before it becomes a reality.

Trajectories

Any vehicle flying in space will be subjected to forces arising from the gravity fields of adjacent bodies. These gravity forces vary in intensity according to the mass of the adjacent body and the reciprocal of the square of the distance of the vehicle from it. Thus, when a vehicle is flying in space near the Earth, the effect of gravitational forces from the Moon, Sun and other planets is small and can often be ignored; but as the Earth is left behind the effect of one or more of these bodies increases until a position is reached when the Earth's gravitational field is no longer dominant.

The Earth is an oblate spheroid, in that the diameter across the Poles is some 23 nautical miles less than that at the Equator, the mean being 6,875.5 nautical miles. For many purposes this oblateness can be neglected. If a vehicle is projected from a point on the Earth's surface, depending upon the velocity and angle of projection it will perform one of three motions, as shown in Fig. 1:—

(1) It may travel along an elliptical path, eventually returning to the Earth's surface. This is the ideal trajectory of a ballistic missile.

(2) It may travel along an elliptical path until its instantaneous centrifugal acceleration outwards equals the acceleration due to gravity inwards; that is, it will be in a state of "continuous fall" and will orbit the Earth.

(3) It may continue to travel away from the Earth until it is acted upon by the gravitational forces from another heavenly body, in which case it is said to escape from the Earth.

Neglecting the effects of atmospheric drag, the rotation of the Earth and gravity forces other than the Earth's, the first two motions can be represented by:—

$$v^2 = g R^2 \left(\frac{2}{r} - \frac{1}{a}\right)$$

where v = instantaneous velocity of the vehicle;
g = acceleration due to the Earth's gravity at the surface of the Earth (32.2 ft./sec.^{2});
r = instantaneous radius of the vehicle from the centre of the Earth;
R = mean radius of the Earth;
a = length of the semi major axis of the ellipse describing the motion.

In both the case of an elliptical trajectory and orbit, the centre of the Earth coincides with the focus of the ellipse which is farthest from the vehicle when it is at its greatest height above the Earth. This point in the flight is known as the apogee, the corresponding low point in an orbit being the perigee. Maximum vehicle velocity occurs at the perigee and is given by:—

$$v_p^2 = g \frac{R^2}{a} \left(\frac{1-e}{1+e}\right)$$

where e = eccentricity of ellipse $= \left(1 - \frac{b^2}{a^2}\right)^{\frac{1}{2}}$

b = the length of the semi minor axis of the ellipse.

Minimum velocity occurs at the apogee, and is given by:—

$$v_a^2 = g \frac{R^2}{a} \left(\frac{1+e}{1-e}\right)$$

In the special case when the eccentricity is zero, a circular

* Department of Aircraft Design, College of Aeronautics, Cranfield.

Missiles and Astronautics . . . .

orbit results; and, since a=r in this instance, the constant vehicle velocity is:—

$$v^2 = g\,\frac{R^2}{r}$$

That is, velocity is inversely proportional to the square root of the distance of the vehicle from the centre of the Earth.

When the vehicle is projected tangentially to, and at, the Earth's surface so that r=R, the ideal, but impracticable, trajectory for a ballistic missile traversing half the circumference of the Earth results. The time for a vehicle in circular orbit to complete one revolution is given by:—

$$t = \frac{2\pi r^{3/2}}{R g^{1/2}}$$

so that the period time is a function of the distance from the centre of the Earth to the power of 1.5.

The third possibility for the motion of the vehicle is the escape path. Estimation of the energy required to overcome gravitational forces shows that:—

$$v_e^2 = 2g\frac{R^2}{r}$$

or the escape velocity is root two times the circular orbit velocity at a given distance from the Earth's centre. For example, projection velocity at the Earth's surface required for escape is 36,800 ft./sec. (6.98 miles/sec.) (neglecting drag).

If a vehicle achieves escape velocity, this speed will not remain constant thereafter, but will decrease under the retarding influence of the Earth's gravitational forces until such a time as the vehicle comes within the influence of a stronger gravity field. Thus, both the Soviet "Lunik" and U.S. "Pioneer" vehicles have become satellites of the Sun.

Escape paths are normally of hyperbolic form. They may, however, be parabolic in the special case when the velocity achieved is exactly that required for escape.

In order to launch a vehicle on a desired path it is thus necessary to achieve the correct velocity and projection angle.

Propulsion

The propulsion system imparts to the vehicle the velocity required. In the previous section it was assumed that the vehicle was projected instantaneously at this velocity. This is not possible in practice, and the propulsion units accelerate the vehicle gradually to the required condition. Whilst it has been suggested that air-breathing engines might be useful in the initial stages of propulsion, rocket engines are almost invariably used.

A rocket propulsion system differs from other types of powerplant in that, in addition to carrying a fuel supply, the oxidant is also provided—making it, in operation, independent of outside environment. The fuel and oxidant are mixed, burnt and expelled rearwards to provide a forward reaction, or thrust, on the vehicle.

As exhaust back-pressure arising from the atmosphere reduces with altitude, thrust increases to a maximum some 11%-12% greater than the sea-level value. For example, the Black Knight rocket engine develops 16,400 lb. thrust at sea level, and this rises to about 19,000 lb. at altitude.

The thrust is the product of the mass and velocity of the exhaust gases. The equation of motion of a rocket vehicle is given by Newton's second law:—

$$\frac{dv}{dt} = \frac{T - D}{gW} - g\sin\Theta$$

where v=velocity at time, t, and weight W.;
T=thrust;
D=aerodynamic drag force;
Θ=inclination of the vehicle to the local horizontal.

If a constant rate of burning of the propellent is assumed, then integration gives:—

$$v_1 = c.\log_e m - gt_1.f(\Theta) - f(D)$$

where suffix 1 indicates the "all-propellent-gone" (all-burnt) condition;
m=ratio of launch weight to final empty (all-burnt) weight = the mass ratio;
c=velocity of the exhaust gases, =Ig, where I is the specific impulse of the fuel, i.e. the thrust per unit weight of fuel per second (inverse of fuel consumption);
$f(\Theta)$ depends upon the flight path. [$f(\Theta)=1$ for a vertical path; $f(\Theta) = \frac{\cos\Theta_1 - \cos\Theta_o}{\Theta_o - \Theta_1}$ for a constant rate of turn path (suffix o indicating launch conditions)];
f(D)=a function of drag; an average value is 700 ft./sec.

This equation clearly shows the importance of the values of m and c in the performance of the vehicle. Both must be as high as possible, and here the advantages of a rocket unit become apparent. It is light in weight for a given thrust, resulting in a high m, and the exhaust velocity is also high.

At the present time all rockets use chemical propellents, i.e. they rely upon molecular reactions, but these propellents may be carried in either solid or liquid form. The solid rocket consists of a charge of propellent, the fuel and oxidant being combined, which is carried in a case with an exhaust nozzle at one end. The propellent is burnt in the case, which thus acts also as a combustion chamber.

In the liquid-rocket type the propellents are contained in different tanks and are supplied to a separate combustion chamber by means of pumps. Sometimes a "monopropellent" is used and then only one tank is required.

The solid rocket is simpler, as it avoids pumps, pipes and the like, and is easier to handle and store in a state ready for immediate use. On the other hand, the liquid type is more efficient, easier to control and, for a large installation, lighter. Its elaborate and large fuel system (that of the Atlas ballistic missile handles about 150 gallons each second) is prone to malfunctioning, and liquid propellents are somewhat difficult to handle.

Liquid oxygen is usually used on large rockets and this is difficult to store, and whilst some fuels are toxic, kerosene is often used. It would seem that solid rockets can be most advantageously used when comparatively high thrusts for short burning times and operational readiness are required. Otherwise liquid rockets would be chosen.

The thrust of a rocket engine is a measure of its size, the aim being to obtain maximum thrust for a minimum weight. Typical variation of liquid-rocket weight with thrust is shown in Fig. 2. As development continues, the optimum size—that giving a minimum weight/thrust ratio—will be increased. At

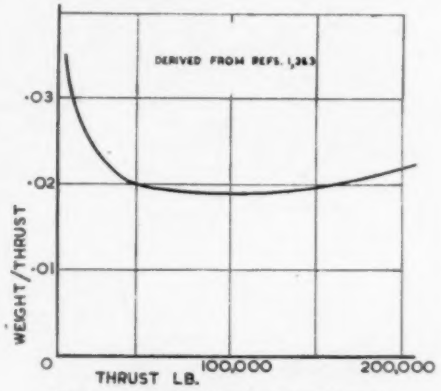


Fig. 2. Weight of liquid rocket engines.

the present time the largest U.S. rocket engines develop about 165,000 lb. thrust, but some £10 million is being spent in the current fiscal year on the development of a 1.0 to 1.5-million-lb. thrust unit for space exploration application. This will be used either singly or arranged in clusters for very large rocket vehicles.

As has been seen, the exhaust velocity, or specific impulse, is the real measure of performance. For present-day liquid chemical rockets the sea-level specific impulse, or S.I., is usually of the order of 250 lb. thrust/lb. fuel/sec. (or sec.), whilst the corresponding value for solid rockets is up to 220 sec. It is anticipated that these values will be improved by development to attain S.I. values of the order of 350 sec., which approaches the theoretical maximum.

Rocket propulsion by means other than chemical fuels has been suggested. One obvious possibility is the application of nuclear power, and a unit relying upon the atomic or fission type of reaction is under development in the U.S. Heat developed during the "splitting" of heavy atomic nuclei is used to expel a suitable substance, such as hydrogen or helium, and it has been estimated that specific impulses that are four or five times higher than those for chemical reactions are possible.

The use of a hydrogen or fusion reaction, which basically produces about three times as much energy as a fission reaction, could result in specific impulses of the order of a

(*Continued on page 469*)

Missile auxiliary power

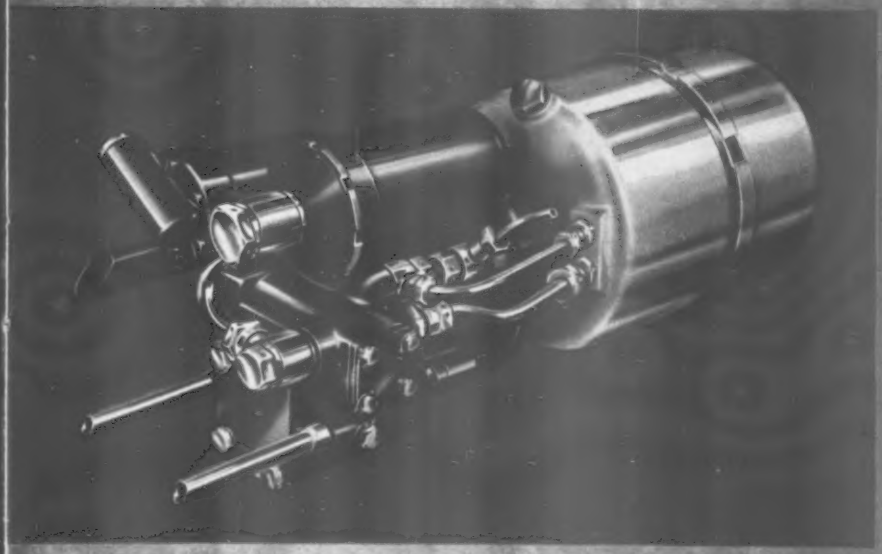
Anticipating the need for auxiliary power in guided missiles, Plessey have developed an Iso-Propyl-Nitrate Power Pack combining flexibility with minimum weight and size.

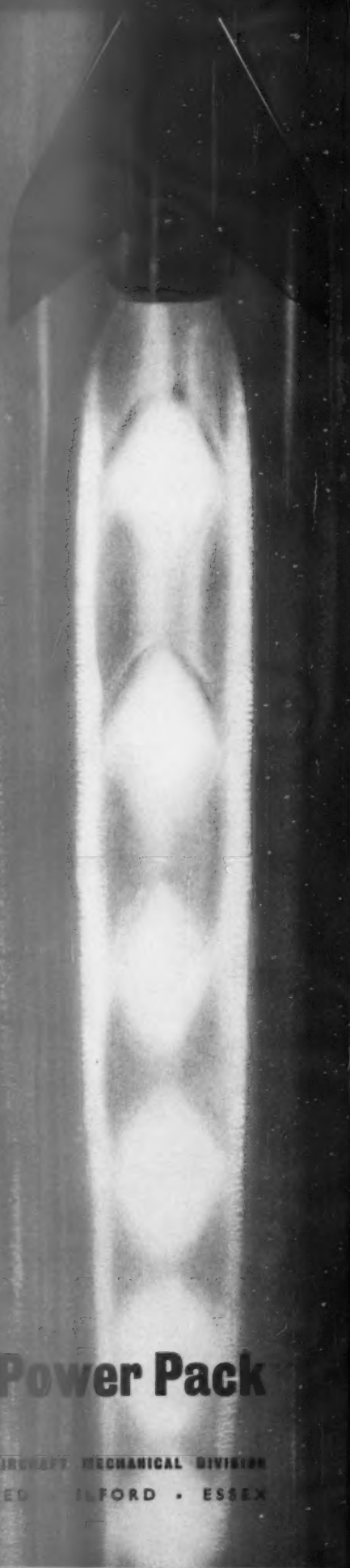
Whether the requirement is for hydraulic power, electrical power or a combination of the two, the Plessey Power Pack can provide the answer. Illustrated is a turbine hydraulic pump unit developing 20 H.P.

Outstanding features

- Compactness
- Can be stored, fully fuelled but unarmed for instant use
- Governed on overall speed range to within 5% both on & off load
- Controlled power output

For qualified engineers who would like to work on advanced equipment of the type illustrated, the opportunities are outstanding. Write to the Personnel Officer for information.





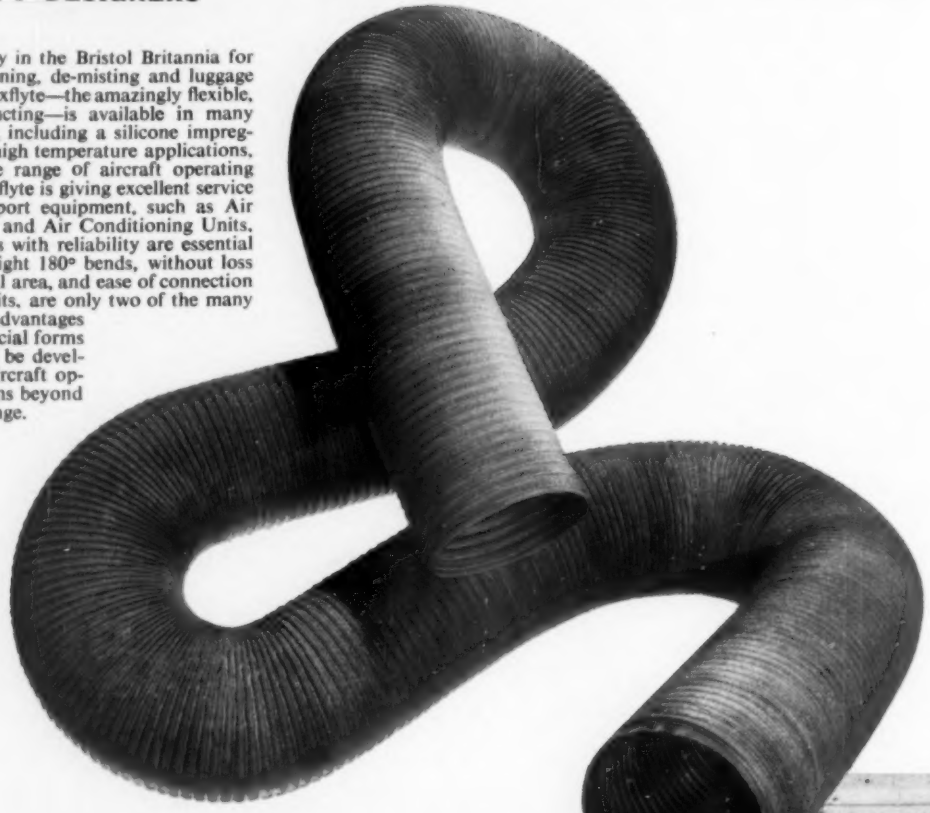
Plessey **Guided Weapon Power Pack**

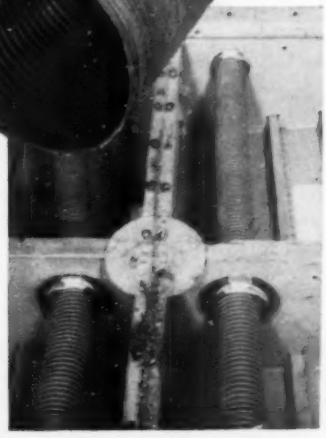
AIRCRAFT AND AUTOMOTIVE GROUP - AIRCRAFT MECHANICAL DIVISION
THE PLESSEY COMPANY LIMITED - ILFORD • ESSEX

The success of FLEXFLYTE *in the air...*

SPECIFIED BY ALL LEADING AIRCRAFT DESIGNERS

Used extensively in the Bristol Britannia for Cabin Conditioning, de-misting and luggage bay heating, Flexflyte—the amazingly flexible, light weight ducting—is available in many standard forms, including a silicone impregnated type for high temperature applications, to meet a wide range of aircraft operating conditions. Flexflyte is giving excellent service on ground support equipment, such as Air Starter Trolleys and Air Conditioning Units, where toughness with reliability are essential requirements. Tight 180° bends, without loss of cross sectional area, and ease of connection to rigid tube units, are only two of the many installational advantages of Flexflyte. Special forms of Flexflyte can be developed to meet aircraft operating conditions beyond the Standard range.





FLEXFLYTE

FLEXIBLE DUCTING LIMITED

SHUNA STREET, MARYHILL, GLASGOW N.W.

Telephone: MARyhill 3311 *Telegrams:* FLEXIDUCT, GLASGOW, N.W.

Representatives throughout the Aircraft Industry:

AVICA EQUIPMENT LIMITED

MARK ROAD, HEMEL HEMPSTEAD, HERTS.

Telephone: Boxmoor 4711 Telegrams: Avica—Hemel Hempstead

AVICA

Missiles and Astronautics . . . .

(*Continued from page 468*)

million seconds. At present the control of such enormous potential has not been achieved, although a start has been made by the development of such apparatus as ZETA.

A further important type of rocket propulsion is that relying upon charged particles, or ions. Electrical fields would be used to ionize the particles, the energy being obtained from solar radiation, a nuclear reactor, or even batteries. The mass flow, and hence thrust, would be very low, but the exhaust velocity would be extremely high.

Such a method would be ideally suited to long journeys in space, where forces opposing motion would be very low, but long duration essential. The working fluid would probably be sodium, or a similar substance, and means would have to be provided to "evaporate" electrons to maintain the vehicle charge neutral.

Further possibilities are the use of electrical arcs, or solar energy to heat and expel a fluid such as hydrogen, or even to use photon, or light, power. In this last case the exhaust velocity would be that of the speed of light, 186,000 miles/sec., but means of radiating intense light beams have yet to be evolved.

Structural Considerations

Although the propulsion unit contributes an important part of the all-burnt weight of a rocket vehicle, the payload, guidance and structure have also to be considered. The structure of a manned aircraft accounts for some 25%-30% of the all-up weight, but the equivalent figure for a large liquid-rocket vehicle is likely to be of the order of one-tenth of this value.

It might be assumed from this that the structural design is not of great importance. Such a conclusion, however, would be false—as the percentage based on unfuelled weight is more like 30% and every effort must be made to reduce it to a minimum.

A typical ballistic missile structure consists of three main components. The centre, main, body forms essentially the propellent tanks, and these are invariably of integral type. At the lower end is a frame, or ring, to which are attached the mountings for the propulsion units. Usually an extension of the tank shell acts as a fairing for the combustion chambers and accessories to reduce drag forces.

The payload is usually carried at the upper end of the tank section and may take one of two forms. In a simple, so-called single-stage vehicle there is a guidance bay and a warhead contained in its re-entry body. Alternatively, there may be a further, complete, rocket vehicle if the vehicle is a multi-stage unit.

The advantage to be gained by staging, that is having a series of separate units carried one above or alongside the others and fired successively, can be seen by reference to the basic performance equation given in the previous section. The final velocity attained is a function of the logarithm of the mass ratio, m. Thus, for two or more stages it is a function of the product, not the sum, of the individual mass ratios.

For example, ignoring gravity and aerodynamic effects, and assuming a specific impulse of 250 sec., a mass ratio of about 100 is required to give escape velocity, if a single-stage rocket is used. This is impossibly high at the present time, but by using three stages the mass ratio required for each stage is no higher than about 4.64.

The need for staging is apparent but, unfortunately, the adoption of this device is not without hazards. Clean separation of the various stages and light-up of the motors in the later stages is difficult and introduces the possibility of malfunction.

An interesting attempt to obtain a compromise is the Atlas ballistic missile, which uses a so-called "1½ stage" system. The three rocket motors are all ignited at launch and fed from common propellent tanks. During the flight the two outer motors and fairing skirt are jettisoned to give two-stage performance, although the effective mass ratio of the first stage cannot be very high. This technique overcomes light-up problems. The Titan ballistic missile, on the other hand, is a true two-stage vehicle.

The majority of the structural problems are associated with the tank section and the re-entry head. The former is basically a pressurized cylinder subjected to axial loads arising from the motor thrust, and to bending from air loads.

Internal pressure is necessary to assist fuel delivery and reduce evaporation, and may also be used to assist in stabilizing the thin tank walls. Stringer stabilization may be required if the lower tank has to be depressurized while the upper tank is full.

As the axial loads are a function of thrust/weight ratio, that is longitudinal acceleration, they will increase as the weight decreases with use of propellent. A high initial thrust/weight ratio will mean a heavy structure; a low one will mean long burning time and hence greater gravity losses on velocity. An optimum must be chosen, and this is found to tend to unity for large liquid rocket vehicles of high mass ratio. For practical purposes a minimum of 1.1 to 1.2 is fixed.

Another structural problem is that caused by the fuel oscillating in the tank—or sloshing. The greater the diameter, the more severe this will be, although damping of the motion is possible. At present, tank diameters appear to be limited to about 10 ft.

If the vehicle is too long there is a control problem associated with the body-bending frequency, and a heavy structure may be required to increase stiffness. Typical length/diameter ratios used for single-stage rockets are 7 to 10.

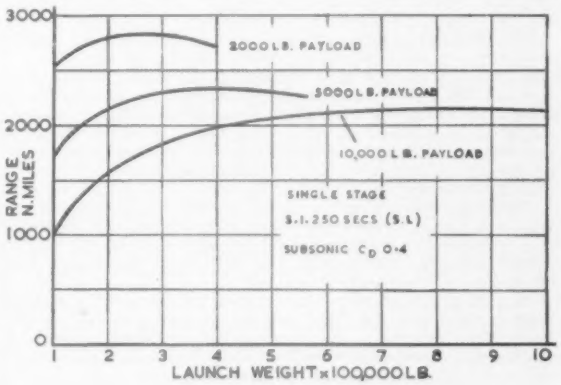


Fig. 4. Single-stage ballistic ranges.

The foregoing indicates that there may well be an optimum, or limiting, size of liquid rocket vehicle, beyond which increase of structure weight has the effect of reducing mass ratio. This is shown by the following formula, which has been derived from curves given by Bossart (Ref. 2):—

$$W_0 = W_F + W_p + 300 + 2.25 \times 10^{-2} W_0 + 4.3 \times 10^{-4} \left(\frac{T_0}{W_0}\right) W_0^{4/3}$$

where W_0, T_0 = launch weight and thrust
W_F = fuel weight
W_p = payload weight

The effect is illustrated in Fig. 3.

The main structure of ballistic missiles is usually either thin steel sheet, as on Atlas, or light-alloy sheet, as used in Titan. As materials and techniques progress the optimum size of the vehicle will increase, and in any case it is not a severe restriction for multi-stage vehicles. The maximum obtainable single-stage mass ratio, with a payload about 2% of the launch weight, is about 12.

Problems associated with the re-entry head are almost entirely due to the considerable heating which is encountered

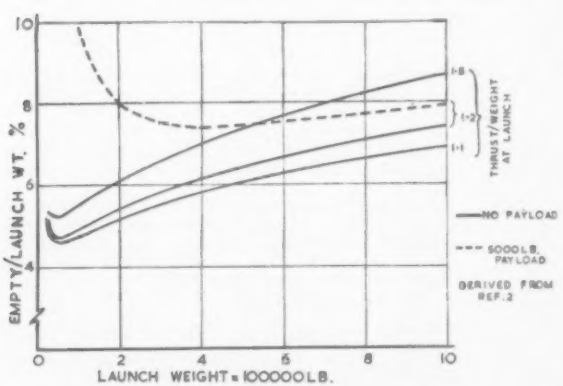


Fig. 3. Empty weight of liquid rocket vehicles.

Missiles and Astronautics . . . .

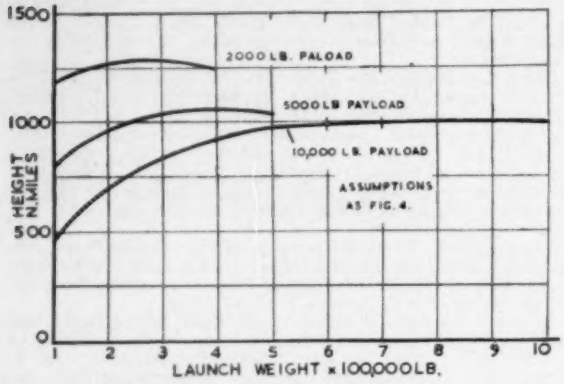


Fig. 5. Single-stage height performance.

as the head enters the atmosphere at high speed. Two approaches to the solution of this important problem have been suggested.

The first method is to surround the warhead with a heavy shield of a metal such as iron, which is insulated from the structure. This shield acts as a heat sink, absorbing the heat energy, and is usually blunt to avoid high local temperatures. Some similar device will be used, with refinements, to enable the satisfactory re-entry of manned craft to be achieved.

The alternative method is the ablation, or eroding, type where the outer surface is allowed to burn, thus dissipating heat. This outer shell would consist of carbon or some similar material.

Guidance and Control

The guidance system is required to ensure that the vehicle attains the correct inclination and velocity at burn-out. It must be very precise in operation; for example, it has been reported that the Soviet "Lunik" was equipped with guidance capable of cutting velocity off to an accuracy of 0.1 second, or about 0.2% on final velocity. The U.S. "Pioneer" failed in the earlier attempt to orbit the Moon because a guidance malfunction resulted in an inclination error of 3.5° and a velocity deficiency of 800 ft./sec.

There are two basic principles in the choice of guidance system. Either a rigid, self-contained system can be used such that once launching has taken place little or no outside influence can be brought to bear; or a flexible system with overriding external control is possible.

Providing the vehicle with a device for interpreting instructions carried on a flight programme is an example of the first type of system. At given time intervals after launch, predetermined commands would be performed, the information being carried on a magnetic tape or similar device.

No allowance can be made for the vehicle encountering unpredictable conditions after launch, and an alternative is pure inertial guidance. In an inertial navigation system the motion of the vehicle in all planes is computed from integrated accelerometer readings, and compared with the initial flight programme, so that correcting control application can be made accordingly.

The accelerometers must be mounted on a platform stabilized in space, and extreme accuracy is essential. This accuracy implies weight, since the use of large gyros enables absolute errors to be reduced. The Thor inertial system is reported to weigh 700 lb. In spite of this weight penalty, the use of an inertial system for ballistic missiles is advantageous. The missile is independent of outside information, other than geophysical properties, and does not betray its presence, making countermeasures difficult.

A pure inertial system can be supplemented by astro fixes and the like.

The alternative approach to the self-contained system is to guide the missile from the ground either by radio control linked with accurate radar and optical tracking, or by a radar beam. The installation in the vehicle is lighter, and a closer control of vehicle behaviour can be obtained. For a ballistic missile there are disadvantages arising from the difficulty of handling more than one missile at a time, radio horizon limitations which means control may end quite early in the trajectory, and the possibility of enemy interference.

Titan uses a pure inertial system, whilst Atlas uses a form of automatic radio control based on radar tracking. The Soviet vehicle used to launch "Lunik" used a combination of pretimed programming with a radar beam for fine corrections.

When a vehicle is flying outside the atmosphere, the only way of applying control forces is to alter the thrust vector, that is to change the magnitude or direction of thrust. Variable-thrust rocket motors are sometimes used, but only in the comparatively small-size range, as there is a large weight penalty in comparison with the fixed-thrust unit.

Whilst large variable-thrust units will probably be required for manned rocket flight, in the case of ballistic missiles, space probes and the like, the required thrust variation is small. Hence fixed-thrust units are used, in conjunction with small vernier motors where necessary.

Thrust direction can be changed by tilting the whole rocket motor, the nozzle alone, or by placing vanes in the efflux gases. Control thus obtained is often coarse and vernier motors are usually added to provide fine control, and may also be used to spin the vehicle to give directional stability. The tilting-chamber technique appears to be favoured in the U.S. and is also used on Black Knight, whilst it is reported that, like the V2, the Soviet "Lunik" vehicle used graphite vanes in the rocket exhaust.

Performance

An indication of the performance which can be expected from large liquid-rocket vehicles appears in Figs. 4 to 6. The first of these figures shows the range of single-stage ballistic missiles flying along optimum trajectories, as a function of payload (guidance plus warhead) and launch weight, whilst Fig. 5 shows the corresponding height performance when they are fired vertically. For a given payload there is a limiting range; for example, for a payload of 5,000 lb. the maximum range for the conditions assumed is about 2,300 nautical miles. Ranges above this can only be achieved by staging.

The effect of using a two-stage vehicle is indicated in Fig. 6. The particular case of 5,000 lb. final payload and 50,000 lb.

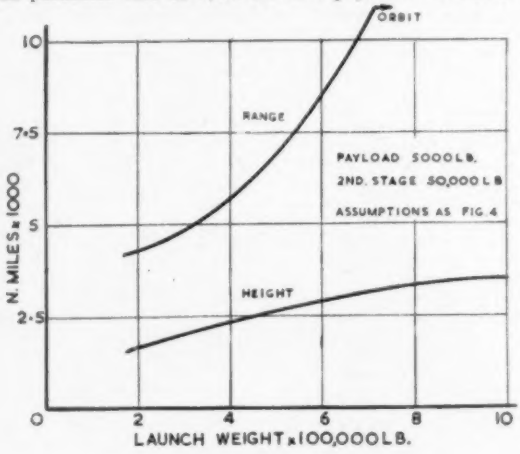


Fig. 6. Typical two-stage performance.

second-stage weight has been taken, and it can be seen clearly that the performance limitation occurs at a launch weight well above the values considered.

Some idea of implied vehicle size can be obtained by the fact that Atlas is reported to weigh rather less than 250,000 lb. at launch, is 85 ft. tall and has a basic diameter of about 10 ft. The million-lb. thrust-rocket engine will be capable of propelling a vehicle of about 900,000 lb. weight, 120 ft. length and 15 ft. diameter, and launching a satellite of about 20,000 lb.

Used in clusters such a power unit will be able to transport materials for the building of space platforms at altitudes of several hundreds of miles. Once this has been achieved the road to space will indeed be open, as vehicles launched from such a device will not have to contend with drag effects and gravity losses will be much reduced.

References

1. Baxter, A. D. "Some propulsion problems of high altitude rockets." July, 1957 (Symposium, Cranfield, 1957).

2. Bossart, K. J. "Design problems of large rockets." July, 1957 (Symposium, Cranfield, 1957).

3. *Aviation Week*. Rocketdyne developments. 6.10.58 (page 65).

Missiles and Astronautics . . . .

INTERNATIONAL MISSILE SURVEY

On this and the following 11 pages is a detailed survey of the more important missiles in service or undergoing development. They are arranged in sections according to their rôle and are alphabetically listed in each section.

Surface-to-surface Strategic Missiles

Atlas (SM-65A)

U.S. intercontinental ballistic missile. In production

Convair began design studies for an ICBM with a 5,000-mile range in 1946. Full-scale development did not become possible until 1954, when progress in the manufacture of more-compact thermonuclear warheads permitted the weight of the missile to be reduced from an impractical 200 tons to something under 100 tons.

A unique "1½-stage" configuration was adopted, in which the 60,000-lb. s.t. LR105-NA-3 sustainer engine is flanked by two 165,000-lb. s.t. LR89-NA-3 boosters, all three engines being gimballed and firing together at take-off. They burn liquid oxygen and RP-1 hydrocarbon fuel, and are produced by North American Rocketdyne, as are the two small gimbal-mounted vernier motors which provide roll stabilization and precise thrust adjustment.

Approximately three minutes after firing, the boosters fall away, carrying with them the flared skirt around the base of the missile. The General Electric nose-cone, containing the warhead, is separated from the main shell shortly after burn-out by means of small retro-rockets.

The main shell of the Atlas is made of thin stainless-steel sheet, forming integral tankage for the propellents. It is pressurized to maintain its shape during ground transport and while the propellents are consumed in flight. Initial production missiles from Convair Astronautics have radio-inertial command guidance, operating in conjunction with General Electric ground radar and a Burroughs computer. Later models will have the Bosch-Arma inertial guidance system developed for the Titan ICBM.

After two failures, the first successful firing of an Atlas A, with booster and vernier motors only, took place on December, 17, 1957. An Atlas B, with full power and separable nose-cone, was fired successfully over a range of 2,500 miles on August 2, 1958. The first full-range flight of 6,325 miles was made on November 28.

Missile 10-B was fired into orbit under Project Score on December 18, followed by the first Atlas Cs on December 23 and January 27, 1959. The latest C models have conical ablating nose-cones of the type fitted to the Jupiter IRBM.

Atlas is scheduled to achieve operational capability with the 1st Ballistic Missile Division of the U.S.A.F. Strategic Air Command by mid-1959. First bases for the complete weapons system (WS-107A-1) will be at Vandenberg, A.F.B., Calif., and Francis E. Warren A.F.B., Wyo., followed by Offutt A.F.B., Nebr., Fairchild A.F.B., Wash., and Forbes A.F.B., Kans. Present plans visualize a total of nine U.S.-based Atlas squadrons, each with 10 missiles.

Length, 80 ft.; diameter 9 ft.; firing weight 195,000 lb.; speed at burn-out, Mach 24 (16,000 m.p.h.); max. range, more than 6,325 miles.

Blue Streak

British long-range ballistic missile. Under development

Intended for R.A.F. Bomber Command with the code-name of Blue Streak, this single-stage ballistic missile is to supersede the Command's present American-built Thor, of which only limited production is intended. Its announced range of 2,875 miles will make it ideally suited for equipping bases in the U.K. and the fact that it is designed for operation from underground launching sites will render it far less vulnerable than the present IRBMs.

Prime contractor for Blue Streak is de Havilland Propellers and the missile will have a liquid-propellent rocket powerplant developed by Rolls-Royce, who have a licence agreement with North American Rocketdyne. Use of this type of engine, rather than the more simple solid-propellent type, was stated recently to give the weapon greater "stretch," enabling it to accommodate any radar countermeasures equipment that may become necessary to overcome enemy jamming.

Airframes will be built by the de Havilland Aircraft Company, with guidance by Sperry. The nose-cone for the thermonuclear warhead is being developed with the aid of the Saunders-Roe Black Knight re-entry research vehicle.

Length, approx. 60 ft.; diameter, approx. 10 ft. designed range, 2,875 miles.

Jupiter (SM-78A)

U.S. intermediate-range ballistic missile. In production

Italy will be the first NATO nation to deploy this IRBM, which was developed by Wernher von Braun's team at the U.S. Army Ballistic Missile Agency, Redstone Arsenal, and is being produced by the Chrysler Corporation.

Jupiter is a comparatively straightforward single-stage weapon, with an over-150,000-lb. s.t. North American Rocketdyne S-3 gimballed liquid-propellent engine. Propellents are liquid oxygen and RP-1 hydrocarbon fuel, contained in integral tanks in the aluminium-alloy body.

The Goodyear nose-cone is conical and is covered with multiple layers of plastics which burn away during re-entry. A Jupiter nose-cone was the first type of U.S. design to survive a re-entry test. It contains a thermonuclear warhead.

The missile has an inertial guidance system produced by the Ford Instrument Company. After burn-out, the nose-cone separates and is provided with vernier propulsion for 45 sec. by its own small Thiokol solid-propellent rocket. Finally the warhead separates from the nose-cone.

First successful firing of a Jupiter

This display of Thor, Snark, and Jupiter shows an interesting variety of surface-to-surface missile types.

Missiles and Astronautics . . . .

occurred in May, 1957, and 29 of the first 38 launchings were completely successful, with partial success in seven more. Training of U.S.A.F. Strategic Air Command squadrons to operate the missile has been under way since January, 1958.

Length, 58 ft.; diameter, 8 ft. 9 in.; firing weight, 105,000 lb.; speed at burn-out, approx. Mach 15; range, over 1,500 miles.

Minuteman (SM-80A)

U.S. intercontinental ballistic missile. In early development stage

By utilizing solid propellents and a smaller thermonuclear warhead, the three-stage Minuteman ICBM will be very much cheaper, smaller, lighter, and easier to handle than the liquid-propellent Atlas or Titan, whilst still offering a range of over 5,000 miles. It will operate from "hard-pad" (underground) launching sites, with automatic or semi-automatic servicing and checking apparatus, so that the missile can be left without normal maintenance for periods of up to a year.

Prime contractor for the weapon system is Boeing, with nose-cone by Avco, inertial guidance by North American Autonetics, and motors by Thiokol and Aerojet, who will underwrite success by producing alternative primary and stand-by designs for each stage. Without the 30-ft.-long first stage, Minuteman will be suitable for use as an IRBM.

It is hoped to begin supplementing the first-generation ICBMs with Minuteman in 1961-62.

Length, 55 ft.; diameter, 7 ft.; firing weight, under 80,000 lb.; range, 5,500 miles. (These data are all approximate.)

Polaris

U.S. Fleet ballistic missile. Under development

Although considerably smaller than Minuteman, this two-stage solid-propellent missile is no less formidable as it is intended to be fired from submerged submarines. Its bases will, therefore, be extremely difficult to pin-point and destroy, whilst its designed range of 1,500 miles, added to the mobility of the launching submarine, brings many worthwhile potential targets within its reach.

Lockheed's Missile Systems Division is the prime contractor for Polaris, with responsibility for developing the airframe and nose-cone and for integrating all components of the missile itself. The motors, by Aerojet, consist of two solid units with a diameter of 53 in. and length of approximately 110 in. and 47 in. respectively for first and second stages. Both motors are contained in the thin-walled steel main body, the first, of about 100,000-lb. s.t., having four nozzles fitted with jet-deflection vanes.

General Electric are contributing the guidance system, which is unusually complex as it must take into account the position and motion of the launching submarine, which will be plotted continuously by a geo-ballistic computer (part of the Ship Inertial Navigation System, SINS). Polaris is expected to be stowed vertically and either floated to the surface or launched like a torpedo from a tube, the mouth of which will be just above the water. The first-stage motor would, in each case, be fired as the missile broke surface.

Progress to date has included many firings of test vehicles, designated AX and A1-X (with guidance) series, some from launching tubes in the water. The blunt nose-cone, which will contain a warhead rather smaller than that of a land-based IRBM, has also undergone considerable testing on X-17 re-entry rockets.

First full-scale tests of an operational A1-P Polaris are expected early in 1960, by which time the U.S. Navy will have in service, the first of the £30-million, 5,600-ton missile-launching submarines, each of which will accommodate 10-16 Polaris missiles.

Length, 26 ft. 6 in.; diameter 4 ft. 6 in.; firing weight, 29,000 lb.; designed range, 1,500 miles.

Regulus 1 (SSM-N-8)

U.S. air-breathing medium-range missile. In service

Production of Regulus 1 by Chance Vought ended in 1958, but several hundred of the 514 missiles that were built remain in service with the U.S. Navy for both operational and training use. They are carried by at least 10 aircraft carriers, four cruisers and four submarines, while other submarines are equipped to guide but not to launch the missile.

Regulus 1 is a simple "flying bomb" which is normally launched from a ramp with the aid of two 33,000-lb. s.t. Aerojet solid-propellent boosters. On carriers the ramp can be replaced by a jettisonable wheeled trolley, and the missile is then launched by means of the ship's catapult, without boosters.

Cruise propulsion is provided by a 4,600-lb. s.t. Allison J33-A-18A turbojet. A simple command guidance system is used and Regulus 1 can be controlled by either surface or airborne transmitters.

The training version, designated KDU-1, has a retractable undercarriage in place of a nuclear warhead, and some of these drones have made as many as 18 flights before being destroyed. Altogether, 850 flights have been made since the first production missile was delivered in 1950, and Regulus 1 has been operational since 1955.

Length, 33 ft.; span 21 ft.; diameter, 4 ft. 6 in.; firing weight, 14,522 lb.; cruising speed, Mach 0.87; range, 575 miles.

Regulus 2 (SSM-N-9)

U.S. air-breathing medium-range missile

Cancellation of U.S. Navy contracts for further development and production of this high-performance "flying bomb," in order to provide increased funds for Polaris, was one of the major surprises of the current U.S. defence budget. Regulus 2 had proved extremely efficient in trial firings from shore bases and from the submarine "Grayback," and gave the U.S. Navy an immediately-available supersonic weapon in the IRBM class, with the added advantage of operation from a difficult-to-detect, mobile, submarine base. Its makers, Chance Vought, still hope to interest other NATO countries in it.

Despite its designation, Regulus 2 has nothing in common with Regulus 1 except that both are air-breathing bombardment missiles with folding wings for stowage aboard ship. It has an advanced swept-wing airframe, is powered by a General Electric J79-GE-3A turbojet (15,000-lb. s.t. with reheat), and carries a nuclear warhead.

Launching is from a ramp, with the aid of a 115,000-lb. thrust Aerojet solid-propellent booster, and in-flight guidance is by an AC Spark Plug inertial system, offering a wide variety of attack "profiles" at all heights from 500 to 60,000 ft.

Length, 57 ft.; span, 20 ft.; diameter, 6 ft.; firing weight, without booster, 23,000 lb.; cruising speed, Mach 2.0; range, more than 1,150 miles at over 60,000 ft.

Snark (SM-62A)

U.S. air-breathing intercontinental missile. In service

Although Snark is a cruise missile, and therefore more susceptible to interception than a ballistic weapon, it offers many advantages, not the least being that it is in service now. It is air transportable, together with all its support equipment, and can be fired within an hour of the squadron's arrival at a chosen site. Being powered by a conventional 15,000-lb. s.t. Pratt & Whitney J57-P-17 turbojet, it is simple to service and handle, and its thermonuclear warhead is reported to be the most powerful fitted to any U.S. missile.

Designed and built by Northrop (airframe by Norair, guidance by Nortronics) for the U.S.A.F. Strategic Air Command, Snark is in every sense a pilotless bomber. The airframe is of conventional swept-wing design, except for the absence of horizontal tail surfaces.

A self-contained stellar/inertial guidance system permits considerable operational flexibility, with attack at any height from ground level to 60,000 ft. and programmed evasive action. Cruising speed is Mach 0.94, and when the "star-tracking" equipment shows that the missile is approaching the target, the fuselage nose containing the warhead separates and follows a ballistic trajectory to the ground at supersonic speed.

Snark squadrons each have 15 missiles and 740 officers and men. The first is based at Presque Isle, Maine, with others already forming in the northern tier of States.

Length, 67 ft. 2 in.; span, 42 ft.; firing weight, approx. 50,000 lb.; cruising speed, Mach 0.94; range, 6,300 miles at 60,000 ft., 2,000 miles at sea level.

Soviet ICBM

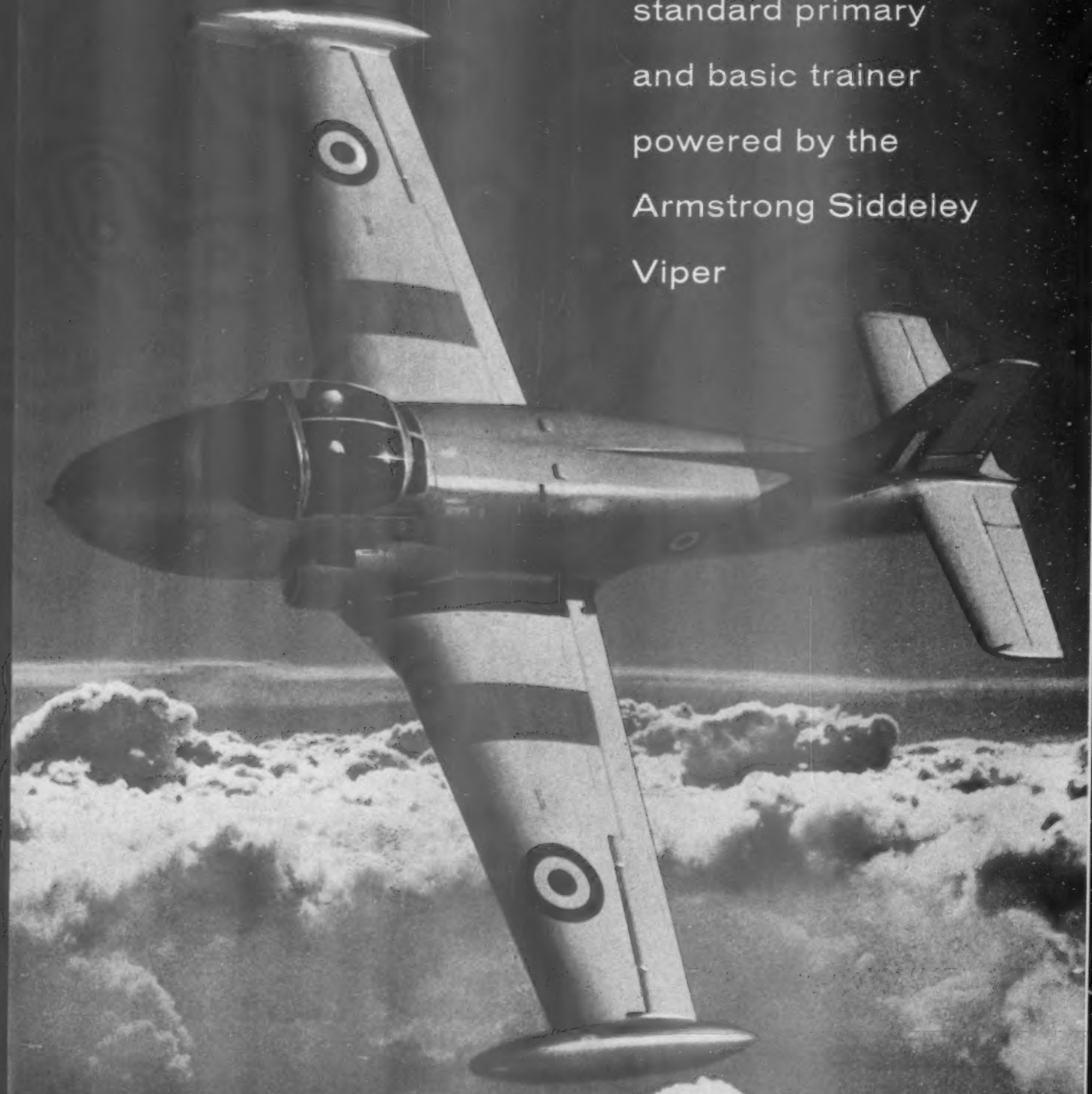
Most of the published information on Russia's intercontinental ballistic missile has been based on conjecture and rumour. The only fact that can be accepted without question is that a U.S radar "listening post" on Mount Samsun

(*Continued on page 473*)

Regulus 2 is powered by a turbojet engine and a solid-propellent booster.

Jet Provost

The Royal Air Force standard primary and basic trainer powered by the Armstrong Siddeley Viper

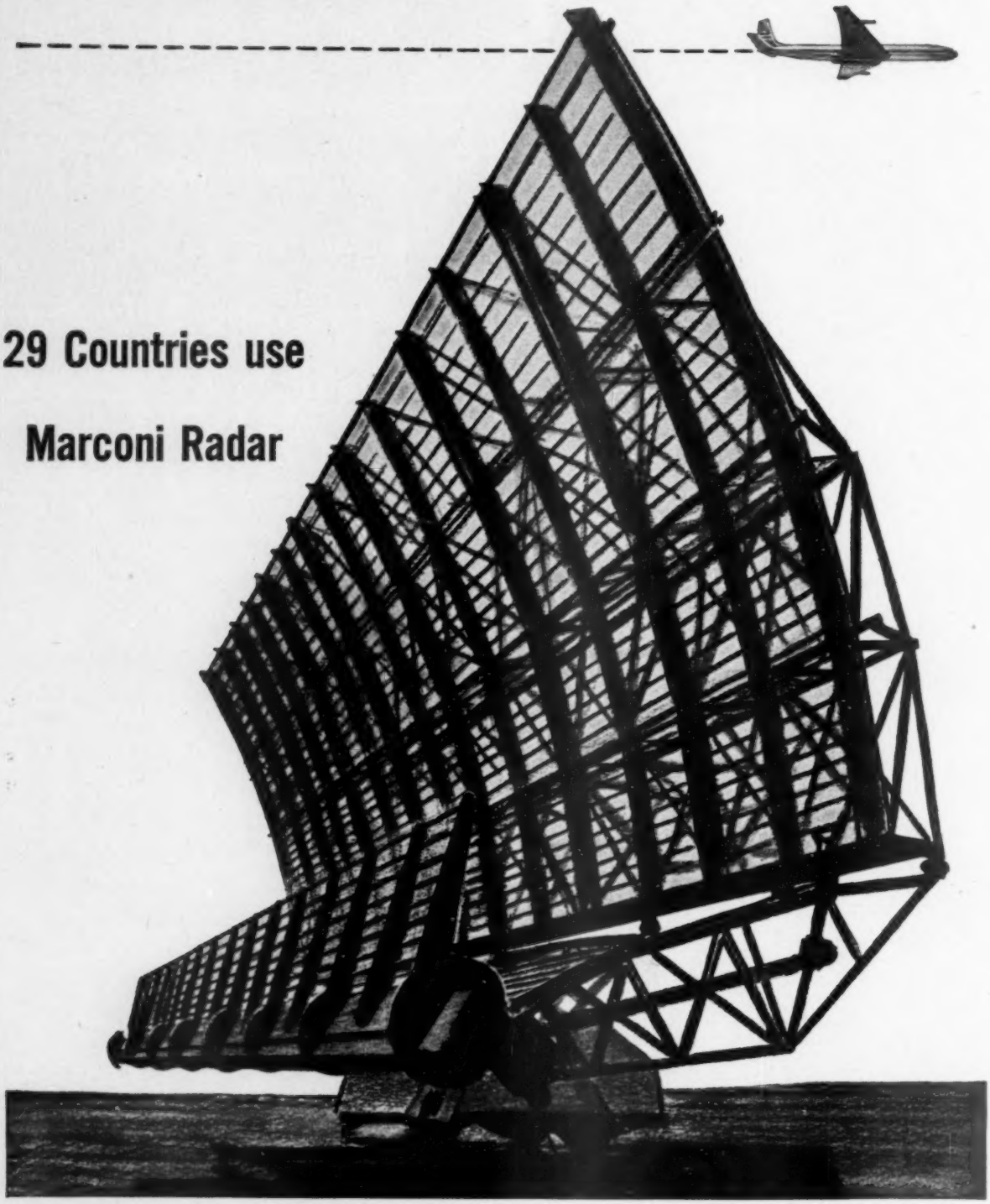


HUNTING AIRCRAFT LIMITED

A Hunting Group Company

LUTON, BEDFORDSHIRE, ENGLAND and at 1450 O'CONNOR DRIVE, TORONTO, CANADA

Marconi in Radar



29 Countries use

Marconi Radar

MARCONI

COMPLETE CIVIL AND MILITARY RADAR INSTALLATIONS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

M 6R

Missiles and Astronautics . . . .

(*Continued from page 472*)

in Turkey picked up a missile which travelled 3,750 miles from Krasny Yar, north of Stalingrad, to St. Peter's Bay, near Vladivostock, in July, 1957, and that further similar firings have followed.

Mr. Krushchev has said that a Soviet ICBM is in service, and told U.S. Senator Humphrey that it has a range of over 8,000 miles. Certainly, Russian successes with satellite launchings imply the availability of very large and powerful launching vehicles, with most efficient guidance systems.

Complex miniaturized instrumentation and advanced (i.e. small, as well as powerful) thermonuclear warheads would hardly be needed by such large missiles, and it must be assumed that a Soviet ICBM *could* be entering operational service. Unconfirmed reports say that it is a three-stage liquid-propellent (liquid oxygen and kerosene) missile, designated T-3 or M-104, with a radio-inertial guidance system of the kind fitted to the initial version of Atlas.

Thor (SM-75A)

U.S. intermediate-range ballistic missile. In service

Like its Army counterpart, Jupiter, the U.S.A.F.'s Thor IRBM is intended for limited production, for operation mainly by America's NATO allies. The only active unit at present is No. 77 Squadron of Bomber Command, based at Feltwell in Norfolk, with three more R.A.F. squadrons due to be equipped this year, making a total first-line strength of 60 missiles. It is not yet known whether Thor will become operational also with the U.S.A.F. Strategic Air Command.

Prime contractor for the Thor weapon system, WS-315A, is Douglas Aircraft, whose technicians were authorized to draw heavily on experience gained with the Atlas and Titan ICBM projects under a "crash programme" instituted in December, 1955. Inevitably, the pace of development led to early troubles and the first four firings were unsuccessful.

On September 20, 1957, Thor No. 5 made a successful flight of 1,350 miles, while No. 8 exceeded its design performance by travelling over 2,800 miles. The weapon was delivered to No. 77 Squadron (albeit incompletely developed) less than three years after its design began.

Thor is a single-stage missile powered by a 150,000-lb. s.t. North American Rocketdyne LR-79 gimballed engine, very similar to that used in Jupiter, and with two small gimballed vernier motors. The body, containing integral tanks for the liquid oxygen and RP-1 propellents, is made mainly of aluminium alloy. The present blunt General Electric nose-cone is identical with that of Atlas B, although a smaller thermonuclear warhead of about 1 megaton yield is carried by Thor. Inertial guidance is provided by an AC Spark Plug AChiever system of the kind used also in the Mace and Regulus 2 air-breathing missiles.

Length, 62 ft.; diameter, 8 ft.; firing weight, 110,000 lb.; speed at burn-out, Mach 15; designed range, 1,500 miles.

Titan (SM-68A)

U.S. intercontinental ballistic missile. Under development

Conceived originally as an insurance against failure of the Atlas programme, the Titan Weapon System 107A-2 has developed so satisfactorily that it is to equip 11 squadrons of the U.S.A.F.'s Strategic Air Command—two more than Atlas.

Titan has a two-stage liquid-propellent rocket and is of classical configuration. Martin's Denver Division is the prime contractor.

The weapon is made mainly of aluminium alloy and has first- and second-stage engines by Aerojet-General. The present blunt nose-cone by Avco may be replaced soon by a conical ablating type, covered with layers of plastics which will burn away during re-entry.

The first stage is powered by an LR87-AJ-1 engine, with two gimballed chambers giving a total thrust of 300,000-lb. Separation of the second stage takes place some time after burn-out of the first stage, and it is then propelled by an LR91-AJ-1 engine which has a sea-level rating of 60,000-lb. s.t. but gives much greater thrust in space. The second stage also has four small vernier motors.

Guidance during the first five minutes after launching is reported to be by a Bell Telephone Laboratory radio command system, but Titan's primary guidance is of the pure inertial type, by American Bosch Arma. This is contained in the nose-cone and re-entry body, which separate from the second stage after burn-out and continue on a ballistic trajectory to the target, carrying a warhead reputedly of 5-20 megatons yield.

One big advantage of Titan, compared with Atlas, is that it is suitable for launching from underground sites. Its development has gone well to date, the first launching on February 6 this year proving successful, after two false starts.

Deliveries to the first S.A.C. underground base at Lowry A.F.B., Calif., are planned for 1961 and Titan is expected to be supplemented rather than replaced by the smaller, solid-propellent Minuteman, which would not have the same tremendous destructive power against buried or well-protected targets.

Length, 92 ft.; diameter 9 ft. 6 in.; firing weight, 221,000 lb.; designed range, 6,350 miles.

Surface-to-surface Tactical Missiles

Asroc

U.S. anti-submarine tactical missile. Under development

Asroc (Anti-Submarine Rocket) is a ship-launched solid-propellent missile, which is being developed for the U.S. Navy by the Ordnance Division of the Minneapolis-Honeywell Regulator Company under a programme dating back to June, 1956. It is wingless, and its flight is programmed by the fire-control system of the launching vessel. U.S. reports have implied that Asroc may be submarine-launched for an underwater-to-air-to-underwater rôle.

Corporal (M4, SSM-A-17)

U.S. tactical ballistic missile. In service

First U.S. ballistic missile to enter service, Corporal is a medium-range bombardment weapon with interchangeable nuclear (kiloton) or high-explosive warheads, for use in combat areas. It has been operational with the U.S. Army since 1954 and with the British Army since 1957 and has provided invaluable training in missile handling and firing.

Operationally, it suffers from the complex and lengthy servicing and preparation for flight that are inevitable with current liquid-propellent missiles. Its eventual replacement by the solid-propellent Sergeant is expected to lead to a great improvement in logistics and firepower.

Corporal is manufactured by the Guided Missile Division of the Firestone Tire and Rubber Company and has a 20,000-lb. s.t. Ryan-built rocket engine, burning nitric acid and aniline. Its radar-Doppler command-type guidance system, supplied by Gilfillan Bros., operates only during the initial stages of flight but gives it all-weather capabilities.

A Corporal battalion of the U.S. Army has 250 men and two operational launchers.

Length, 46 ft.; diameter, 2 ft. 6 in.; span of fins, 7 ft.; firing weight, 12,000 lb.; speed at burn-out, Mach 3; range 75-100 miles.

Honest John (M31)

U.S. unguided tactical bombardment rocket. In service

Built in very large numbers since 1951 by Douglas and Emerson Electric, Honest John has the virtue of being extremely simple and mobile. Although unguided, it is spin-stabilized during launching by a Thiokol M7 rocket-motor, exhausting through four tangential nozzles aft of the bulbous warhead, and this feature ensures a high degree of accuracy.

Honest John is powered by a type M3 solid-propellent motor manufactured by the Hercules Powder Co. and carries a 1,500-lb. high-explosive or nuclear warhead. It can be air-lifted by the Sikorsky H-37 (S-56) helicopter, and is fired from a self-propelled launcher, if necessary by as few as six men.

In world-wide service with the U.S. Army, this weapon is scheduled for delivery also to the Japanese and Federal German defence forces.

Length, 27 ft. 3 in.; diameter, (warhead) 2 ft. 6 in.; span of fins, 9 ft. 1 in.; firing weight, approx. 5,900 lb.; speed at burn-out, Mach 1.7; range, 20 miles.

Lacrosse (SSM-A-12)

U.S. tactical bombardment missile. In service

Lacrosse is a solid-propellent field artillery missile which is being manufactured for the U.S. Army by Martin's Orlando Division, after initial development by the Cornell Aeronautical Laboratory who do no production work. Despite its comparatively small size, it carries a very powerful high explosive or tactical nuclear warhead, for use against "hard-skin" targets over ranges up to 20 miles, and offers great accuracy.

The solid-propellent rocket is manufactured by Thiokol and the guidance system by Federal Telecommunications Laboratories. Although of the radio-command type, the latter can be used in conjunction with a radar tracking device to attack targets whose precise position

Missiles and Astronautics . . . .

is known at night or in bad visibility.

The missile is launched by remote control from a standard 2½-ton truck, sited if necessary well behind the missile operator in his front-line position. It can be air-lifted by helicopter.

Well over 2,000 production rounds are reported to have been delivered to the U.S. Army, and Lacrosse is expected to equip also the Canadian Army.

Length, 19 ft. 2½ in.; diameter, 1 ft. 8½ in.; span of wings, 9 ft.; firing weight (estimated), 5,000 lb.; range, 20 miles.

Little John (M47)

U.S. unguided tactical bombardment rocket. Entering service

Developed and fired successfully in four months, at Redstone Arsenal in 1956, this unguided artillery rocket is smaller and even more simple and mobile than Honest John. It is being manufactured in large quantities by Emerson Electric, with solid-propellent motor by Allegany Ballistics Laboratory, and was first issued in 1958 to the 101st Airborne Division at Fort Campbell, Kentucky, for training and development of combat techniques. This underlines the fact that Little John, with its lightweight launcher and ground equipment, can be air-lifted in small aircraft and helicopters such as the Sikorsky H-34 (S.58).

Although Little John's warhead is smaller than that of Honest John, it seems probable that it will eventually replace this weapon, in partnership with Lacrosse.

Length, 12 ft.; diameter, 12½ in.; span of fins, 2 ft. 9 in. firing weight, 980 lb.; range 10 miles.

Mace (TM-76)

U.S. air-breathing tactical bombardment missile. In service

Mace is a highly advanced "flying bomb" developed from the TM-61 Matador, which it has superseded in production at Martin's Baltimore Division. Matador squadrons of the U.S.A.F., based throughout the World, will re-equip progressively with the newer weapon, beginning in the near future with those in Germany.

A "flying bomb" type of missile, the Martin Mace is used by the U.S.A.F.

There are two versions of Mace, with differing self-contained guidance systems. The TM-76A has Goodyear ATRAN guidance, which relates a film strip to the terrain over which the missile flies and makes possible a programmed attack at high or low altitudes. The TM-76B has an AC Spark Plug AChiever inertial system.

In other respects the two are similar, with folding wings instead of the removable wings of Matador; power is provided by a 5,200-lb. s.t. Allison J33-A-41 turbojet. The rounded nose carries a heavier nuclear warhead than Matador, and Mace has a longer range.

The complete Mace weapon system includes two remarkable Goodyear vehicles, carried on huge balloon tyres. These consist of a "Translauncher" combined transporter/launcher and a "Teracruzer" tractor which serves as a prime mover for all necessary support equipment. A 100,000-lb. s.t. Aerojet jettisonable solid-propellent booster is used for launching the missile.

Length, 44 ft.; diameter, 4 ft. 6 in.; span of wings, 23 ft.; firing weight, about 13,800 lb.; cruising speed, Mach 0.9; range, over 650 miles.

Missile Able

U.S. tactical bombardment missile. Under development

One of the new-generation weapons under development for the U.S. Army, Missile Able will be a lightweight field artillary missile with a range of up to 70 miles. Six companies—General Electric, Minneapolis-Honeywell, Armour, Cornell, Martin and Douglas—are reported to have received design study contracts for it. In addition, Chance Vought are working on a somewhat similar weapon, of which a test vehicle was fired successfully at Redstone Arsenal in January of this year, under a U.S. Army Ordnance Missile Command evaluation programme.

Pershing

U.S. medium-range tactical ballistic missile. Under development

This 500/700-mile bombardment weapon is a strange item to find in the U.S. Army inventory, as a 1955 ruling limited Army missiles to a range of 200 miles, implying a battlefield support rôle only. However, this has now been relaxed.

Pershing's initial design was by the Army Ballistic Missiles Agency at Redstone Arsenal. Martin's Orlando Division was chosen in 1958 from some 30 competitors as prime contractor for development and production.

Fifty evaluation and test models are to be built, for tactical firing in late 1960 or 1961. They will be two-stage solid-propellent missiles, with parachute recovery of the instrumented upper stage, which will separate at around 40,000 ft. altitude.

Production rounds will have inertial guidance by the Eclipse Pioneer Division of Bendix, a nuclear warhead, and solid-propellent motors by Thiokol. It is hoped to save time and expense by adapting some of the lightweight ground equipment now used for the Redstone missiles which Pershing is designed to replace.

Length, approx. 30 ft.; diameter (test vehicle), 2 ft.; range, any selected distance of up to 500/700 miles.

Redstone (M5, SSM-A-14)

U.S. medium-range tactical bombardment missile. In service

Developed at Redstone Arsenal under the supervision of Dr. Wernher von Braun, this field artillery missile drew heavily upon his earlier experience with the wartime V-2 rocket. The main difference is that its nose portion, containing the 3-ton high-explosive or high-yield nuclear warhead and guidance system, is separated after motor burn-out. This portion is fitted with small stabilizing fins.

Redstone has a 75,000-lb. s.t. North American Rocketdyne A-7 engine, burning liquid oxygen and alcohol, and Ford Instrument inertial guidance, based on play-back signals from a tape fed into the missile before launching. Its simple cylindrical airframe of wrapped aluminium is manufactured by the Chrysler Corporation.

First fired in May, 1953, Redstone entered service with the U.S. Army's 40th Field Artillery Missile Group three years later and has since been issued also to at least two battalions of the 333rd F.A.M.G., each made up of some 600 men.

Length, 63 ft.; diameter, 5 ft. 10 in.; span of fins, 12 ft.; firing weight, 45,000 lb.; range, 180-250 miles.

Robot 315

Swedish ship-based tactical bombardment missile. In service

This surface-to-surface weapon is unique in that its sustainer motor is a pulse-jet, the air intake for which comprises an annular grille in line with the wing trailing-edges. It is ramp-launched, with initial propulsion by four solid-propellent booster rockets, contained within the body and exhausting through individual nozzles aft of the pulse-jet intake grille. No details of the guidance system are available, but it is stated to be suitable for all-weather use and controls the weapon through pivoted foreplanes.

Robot 315 was developed by the Robotbyran (Guided Weapons Bureau) of the Royal Swedish Air Board and is being produced by the Air Force Central Workshops, with the help of civilian subcontractors. Airframe testing began in 1953, followed by the first firing of a complete missile in January, 1954.

Length, approx. 22 ft.; span of wings, 8 ft.; firing weight, over 3,000 lb.; cruising speed (estimated), Mach 0.85.

S.E.4200

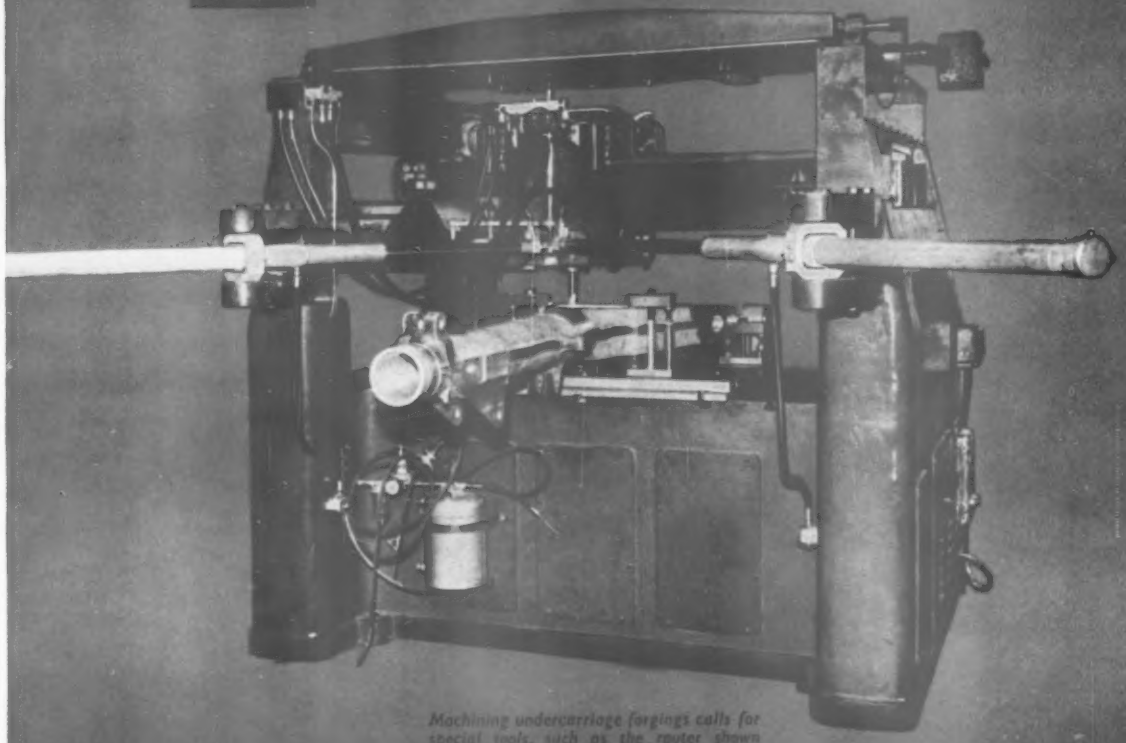
French tactical air-breathing bombardment missile. In service

This "flying bomb" takes the form of a small tailless swept-wing aeroplane, powered by an integral ramjet engine contained within its fuselage. It is launched from a simple zero-length ramp with the assistance of two solid-propellent booster rockets, and carries its high-explosive charge in an underslung pod.

The S.E.4200 is gyro-stabilized in flight, through trailing-edge elevons and wing-tip rudders, with a sensitive altimeter to maintain the correct cruising height. Guidance is by radio command, for which tracking flares are provided on the fin-tips, and a telemetering device

(*Continued on page 475*)

PRODUCTION FACILITIES



Machining undercarriage forgings calls for special tools, such as the router shown above, for which ELECTRO-HYDRAULICS' designers have produced hydraulic control gear enabling the cutter to follow a pattern and to reproduce the form with speed and accuracy.

Facilities for efficient production of undercarriages and hydraulic equipment at *ELECTRO-HYDRAULICS* are unsurpassed elsewhere. This is why you can rely on the *quality* of our products, the *promptness* of our delivery and on our *competitive prices*.

ELECTRO-HYDRAULICS LIMITED

WARRINGTON
Telephone: Warrington 53241

MEMBER OF THE DOWTY ORGANISATION

. . . and before I could get a word in edgeways, he told
me that the amount of fuel an aircraft takes has gone up
from 3,000 gallons to 20,000 gallons in the
past ten years, and that AIR **BP** is building fuellers
which will hold 10,000 gallons each, and deliver them
at 750 gallons a minute.

Too much liquid's very fattening, you know.

AIR BP

THE AVIATION SERVICE OF BRITISH PETROLEUM

Missiles and Astronautics . . . .

(*Continued from page 474*)

enables the operator to dive the weapon into the target by a radio signal at the appropriate time.

Sud-Aviation have produced the S.E.4200 in small numbers for service with the French Army, the launching ramps normally being mounted on light trucks.

Length, with boosters, approx. 12 ft. 6 in.; without boosters, 10 ft.; span of wings, 7 ft. 1 in.; firing weight, 660 lb.; cruising speed, approx. Mach 0.9; normal range, 62 miles.

Sergeant

U.S. medium-range tactical ballistic missile. Under development

Designed and developed by the Jet Propulsion Lab., Sergeant is one of the new generation of solid-propellent battlefield missiles with which almost all U.S. Army field artillery units will be equipped eventually. It is to be produced in large numbers by Sperry's Utah Engineering Lab., with a single-stage solid-propellent motor of over 50,000-lb. s.t. supplied by Thiokol, and will replace the liquid-propellent Corporal.

Sergeant has an inertial guidance system of Sperry design and can carry interchangeable nuclear or high-explosive warheads. It is launched in a near-vertical position from a combined erector/launcher which, like the missile itself and the other ground components, is transportable by air and by standard Army vehicles.

Length, approx. 30 ft.; diameter, 3 ft.; span of fins, 7 ft. 8 in.; firing weight, 12,000 lb.; range, over 100 miles.

Soviet Ballistic Missile T-5C (?)

Unguided field artillery missile. Probably in service

The only Russian missiles of which photographs have been issued are the four types of surface-to-surface weapon and single type of surface-to-air weapon which were displayed in the 1957 parade through Moscow marking the 40th anniversary of the Revolution. The smallest of the bombardment missiles is an unguided single-stage spin-stabilized Army support rocket, possibly designated T-5C.

Eight of these rockets were shown, each carried on an elevating, rotating ramp on a Type 1955 (JS.3) amphibious reconnaissance AFV chassis. They are very similar to the American Honest John, but smaller, with a solid-propellent motor and bulbous warhead. The following data are estimated:

Length, 25 ft.; span of fins, 3 ft.; firing weight, 3,500 lb.; range 10 miles.

Soviet Ballistic Missile T-5B (?)

Unguided field artillery missile. Probably in service

Reportedly designated T-5B, this missile is similar to the so-called T-5C, but larger, and may be an earlier less-advanced model. Eight were included in the 1957 parade, each mounted on a tracked transporter/launcher somewhat larger than the JS.3, with enclosed accommodation for the crew. The heavy ribbed casings over the body of the missile may be either for protection or to provide some form of heating to keep the solid-propellent motor serviceable in very cold weather. Estimated data:

Length, 31 ft.; span of fins, 3 ft. 3 in.; firing weight, 6,000 lb.; range, 15 miles.

Soviet Ballistic Missile T-7A (?)

Guided field artillery missile. Probably in service

Carried on a similar vehicle to the larger of the two bulbous-nosed spin-stabilized rockets, the T-7A (designation unconfirmed) appears to have movable tail-fins, implying some form of guidance. Like the other Russian artillery missiles displayed in 1957, it is extremely simple and straightforward, with a cylindrical body, a single-stage motor, and a pointed nose-cone, probably with alternative nuclear or high-explosive warheads. Data estimated:

Length, 35 ft.; diameter, 3 ft. 4 in.; firing weight, 10,000 lb.; range, 50 miles.

Soviet Ballistic Missile T-1 or M-101 (?)

Guided medium-range tactical bombardment missile. Probably in service

Largest of the four bombardment missiles revealed in 1957, and reportedly designated T-1 or M-101, this weapon is almost certainly an early example of Russian military missile design on much the same lines as the American Redstone.

The examples shown had liquid-propellent rocket engines (said to be of 77,000-lb. s.t.), with V-2-type control vanes in the rocket efflux, as well as movable elevators in the tail-fins.

A girder-type transporter, towed by a large tractor, has open seats for a 16-man crew. Data estimated:

Length, 55 ft.; span of fins, 12 ft.; firing weight, 30,000 lb.; range up to 450 miles.

Subroc

U.S. tactical anti-submarine missile. Under development

Subroc (SUBmarine ROCket) will be a long-range rocket-propelled missile, for launching from submarines against enemy submarines and surface craft. Although it will make its journey to the target through the air, it will be suitable for firing from above or below the surface, and will carry a nuclear warhead.

Goodyear are prime contractors for the weapon system under a contract awarded last June, and are working in collaboration with the Naval Ordnance Lab. at White Oak, Silver Spring, Maryland. The solid-propellent motor is being developed by Thiokol, while the Librascope and Kearfott companies have the difficult task of perfecting sonar equipment capable of detecting submarines within the weapon's 25-mile range.

Having detected a target, this equipment will compute its course and speed and fire the missile. After burn-out, the rocket will fall away, leaving the warhead to continue on a ballistic trajectory.

Surface-to-surface Anti-tank Missiles

Fairey Missile

British anti-tank missile. Under development

No details are available of this weapon, which has been described as *the* anti-tank missile for the British Army. This implies a missile of major importance, and an official statement has been made that it will be so effective that it will "sweep the heavy tank from the battlefield." It must, therefore, be comparatively sophisticated, with a range, accuracy and all-weather capability unobtainable with a small wire-guided weapon. Development has been under way for well over a year.

Malkara

Australian anti-tank missile. In initial service

Largest anti-tank missile of which details have yet been released, Malkara is an extremely potent weapon, capable of knocking out any known AFV with a single hit and with a proven accuracy of almost 100%. Its development began in 1951 as an all-Australian project, centred in the Government Aircraft Factory, near Melbourne, and trials of the weapon were started at Woomera more than three years ago. A batch of 150 rounds is being used by the British Army for evaluation and training in Scotland.

Malkara is of traditional British cruciform-wing-and-tail layout, and is controlled by means of its pivoted wings. It has a two-stage solid-propellent motor in a single casing and carries a shaped-charged warhead with a reported weight of over 50 lb. Launching is by remote control, from a lightweight ramp on any standard small vehicle, and the weapon is said to have a wire-type command guidance system.

Length, 6 ft. 6 in.; span of wings, 2 ft. 8 in.; firing weight, 200 lb.; speed approx. 275 m.p.h.; range, over 6,000 ft.

Mosquito

Swiss anti-tank missile. Available for service

Known originally as the Cobra, this infantry-launched anti-tank missile has been under development by the Contraves and Oerlikon companies since 1956 and is now available "off-the-shelf." It is of extremely simple design, comprising a cylindrical glass-fibre body and detachable cruciform wings, each with a spoiler-type control in the trailing-edge. Propulsion is by two-stage solid-propellent motor in a single casing, and guidance by wire-command, with gyro-stabilization. A 7.3-lb. hollow-charge warhead is fitted.

Length, 3 ft. 1 in.; diameter, 5 in.; span of wings, 2 ft.; firing weight, 23 lb.; speed, 200 m.p.h.; range, 6,500 ft.

Pye Anti-tank Missile

British anti-tank missile. Under development

Although approaching the size of Malkara and carrying a heavy shaped-charge warhead, this private-venture wire-guided weapon has been designed so that it can be carried for short distances and operated by a single infantryman. This implies also the capability of being carried by helicopters and light aircraft.

The Pye anti-tank missile has a cylindrical metal fuselage containing the two-stage solid-propellent rocket motor,

Missiles and Astronautics . . . .

which is produced by Bristol to Pye design and incorporates the jet-deflection control system. Wire-guidance bobbins are carried on the tips of two of the cruciform sheet-metal wings, with tracking flares on the other two. The missile is launched from a lightweight tubular ramp and is controlled visually by means of a thumbstick and 20-lb. control box.

Length, 5 ft.; diameter, 6 in.; span of wings, 2 ft.; firing weight, approx. 80 lb.; performance secret.

S.S.10 (Nord 5203)

French anti-tank missile. In service

Despite its small size, this wire-guided missile is claimed to be capable of penetrating 16 in. of armour-plate. It is also battle-proven, having been used successfully by the Israeli Army during the Sinai campaign of 1956.

Very large numbers have been delivered by Nord-Aviation to the armies of France, Israel, Federal Germany, Sweden and the United States. Production is reported to be at the rate of 500 rounds per month.

The S.S.10 consists simply of a cylindrical metal body, fitted with cruciform wings and an 11-lb. hollow-charge warhead. It is powered by a solid-propellent motor, so designed that it burns initially at high thrust to serve as a booster.

Wire-guidance on a line-of-sight flight path is achieved by means of a small joystick-type control, which actuates spoilers that are inset in the wing trailing-edges. The missile rotates slowly during flight.

Length, 2 ft. 10 in.; diameter, 6½ in.; span of wings, 2 ft. 5½ in.; firing weight, 33 lb.; speed, 185 m.p.h.; range, 5,000 ft.

S.S.11 (Nord 5210)

French anti-tank missile. In service

Larger, heavier and with a higher performance than the S.S.10, the wire-guided Nord-Aviation S.S.11 is intended to be launched from trucks, helicopters and aircraft rather than by infantry. It utilizes most of the proven design features and guidance techniques of the smaller weapon, the main difference being that its flight path is controlled by deflecting the efflux of its rocket-motor instead of by aerodynamic surfaces. The normal warhead is a 13-lb. hollow charge.

The S.S.11 is already in service with the French Army and Navy and is being evaluated in Britain, including firing trials from Twin Pioneer aircraft. Many other countries are likely to adopt it.

Length, 3 ft. 6½ in.; diameter, 6 in.; span of wings, 1 ft. 7 in.; firing weight, 69 lb.; speed, 435 m.p.h.; range, just over 2 miles.

Vigilant

British anti-tank missile. Available for service

Developed by Vickers-Armstrongs as a private venture, under the designation of V.891, this wire-guided missile can be carried and fired easily by one man, yet combines a high degree of accuracy with the ability to penetrate the armour of almost any AFV. It comprises a cylindrical light-alloy body, fitted with a cruciform of plastics wings which span only 11 in. Pneumatically actuated control surfaces are hinged on the wing trailing-edges.

The Vigilant has an I.C.I. two-stage solid-propellent rocket motor and carries a hollow-charge warhead of new design, with retractable contact probe. It can be transported, complete with lightweight tubular launcher, in a waterproof canvas bag, the whole package weighing only some 35 lb.; or in a metal canister which can be used also as a zero-length launcher, in which form the "weapon system" weighs 45 lb.

Guidance is by thumbstick control, the operator following the missile's path visually with the aid of a tracking flare. A single operator can be in charge of a series of dispersed missiles, the firing leads from which need only be connected successively to the thumbstick control unit.

The Vigilant is reported to be one of several types under evaluation by the U.S. Army as a replacement for the now-defunct Aerophysics SSM-A-23 Dart.

Length (probe retracted), 2 ft. 9 in.; diameter, 4½ in.; span of wings, 11 in.; speed, approx. 350 m.p.h.; range, approx. 1 mile.

Air-to-surface Missiles

B.B.10

French air-to-surface stand-off bomb

The B.B.10 was developed by Sud-Aviation for the French Air Force as a stand-off bomb for delivery by the Vautour jet-bomber, but it is not known whether the project is still active. In the form displayed in 1957, it was powered by a smokeless solid-propellent motor and guided by radio command.

Guidance included a small television camera and transmitter in the missile, by means of which the controller in the launching aircraft could "see" the target through a window in the missile's nose and so ensure accuracy of attack over a considerable range. The warhead comprised a high-explosive charge of some 400 lb.

Length, 11 ft.; span of tail-fins, 2 ft. 8 in.; firing weight, 900 lb. (These data are approximate.)

Blue Steel

British air-to-surface stand-off bomb. Under development

Avro's Blue Steel is intended as the primary armament of the Vulcan and Victor bombers, which will carry it partly enclosed in the bomb-bay.

Blue Steel has a tail-first aeroplane configuration, and is controlled by pivoted delta foreplanes and inboard ailerons on its rear-mounted delta wings. The ventral fin folds to provide ground clearance for take-off.

Guidance will be by an inertial system developed by Elliott Bros. (London), Ltd., in conjunction with the M.o.S. and R.A.E. No further details have been released officially, but the powerplant is reported to be, initially, a de Havilland Double Spectre twin-chamber liquid-propellent rocket engine, running on H.T.P. and kerosene and giving a total of some 16,000-lb. s.t.

An Avro executive in Australia stated last year that Blue Steel would be flight-tested at Woomera during 1959 from a Vulcan, and that it was intended to cruise at supersonic speed at heights up to 60,000 ft., after release 400 miles from the target. Flight tests from a Valiant are believed to have been under way for some months.

Length, approx. 35 ft.; span of wings, approx. 16 ft.; weight and performance secret.

Bullpup (ASM-N-7)

U.S. air-launched tactical missile. In service

Produced by Martin's Orlando Division, Bullpup is a powerful guided bomb of extreme simplicity. It consists of a cylindrical body, housing any one of a variety of 250-lb. high-explosive warheads, and is powered by a solid-propellent rocket developed by Allegany Ballistics Lab. and produced by Aerojet. Guidance is by radio-command from the launching aircraft, via pivoted cruciform foreplanes, the pilot keeping the missile in sight by means of tracking flares.

Production for the U.S. Navy and Marine Corps is reported to be at the rate of some 600 rounds per month.

The missile is small enough for aircraft like the FJ-4B Fury to carry six on underwing pylons. An improved version known as White Lance (*q.v.*) is under development for the U.S.A.F.

Length, 11 ft. 2 in.; diameter, 12 in.; span of wings 3 ft. 1 in.; firing weight, 540 lb.; speed, Mach 1.8; range up to 5 miles.

Corvus

U.S. air-launched tactical missile. Under development

Under development by Temco since January, 1957, for the U.S. Navy, Corvus is primarily an air-to-surface stand-off missile for use in penetrating heavily-defended areas and against surface ships. Reports indicate that it may also be used in a countermeasures rôle, to home on enemy radar and missile sites, over ranges up to 50 miles.

Corvus is powered by a Reaction Motors Patriot liquid-propellent rocket engine and will have a guidance system manufactured by the Texas Instrument Co. and W. L. Maxson Corp.

Crossbow (GAM-67A)

U.S. air-launched bomber-defence missile

Crossbow is, or was, a countermeasures weapon, intended to be launched from U.S.A.F. strategic bombers and to home on enemy radar and missile sites. It was under development by Radioplane a year ago, with a Westinghouse J81 (Rolls-Royce Soar) turbojet and Bendix-Pacific telemetering equipment for evaluation trials at Holloman A.F.B.; it may have been dropped.

Hound Dog (GAM-77)

U.S. air-to-surface stand-off bomb. Under development

The U.S.A.F. pins great faith on this slender weapon which, in partnership with the Quail decoy missile, should maintain the deterrent power of the B-52G Stratofortress until the supersonic B-70 Valkyrie is ready for service in the mid-sixties. Prime contractor is North

American's Missile Division, under contracts dating back to 1957. A production order was placed last November, with first deliveries of the fully developed weapon scheduled for 1960.

In brief, Hound Dog has a tail-first aeroplane configuration, with a 7,500-lb. s.t. Pratt & Whitney J52 turbojet in a pod under its body. Guidance is by a North American Autonetics inertial system.

One of two alternative payloads can be carried. The first, covered by the weapon system designation WS-131B, consists of a thermonuclear warhead of very high yield. The second, under WS-132A, is reported to comprise countermeasures equipment.

Length, approx. 40 ft.; span of wings, approx. 13 ft.; speed, approx. Mach 1.5; range, approx. 350 miles.

Petrel

U.S. air-to-underwater tactical missile. In service

Although now operational only with the U.S. Naval Reserve, Petrel has been for several years the most reliable and efficient airborne anti-shipping weapon available to American maritime reconnaissance squadrons. Developed in 1949-51 by the National Bureau of Standards and produced by the Fairchild Guided Missiles Division, it consists of a standard Mk. 13 torpedo fitted with underwater radar homing and a jettisonable airframe "package" including a 1,000-lb. s.t. J44 turbojet.

It is launched from beneath the wings of Neptune and Marlin aircraft.

Length, 24 ft.; span of wings, 13 ft.; launching weight, 3,800 lb.; speed, Mach 0.7; range, 5 miles.

Quail (GAM-72)

U.S. air-launched bomber-defence missile. Under development

Classed as an air-launched diversionary missile, Quail has been developed by McDonnell for the U.S.A.F. Strategic Air Command. It consists of a small tailless aircraft made of glass-fibre and powered by a General Electric J85 turbojet of around 2,500-lb. s.t.

Payload comprises electronic countermeasures equipment produced by Ramo-Wooldridge, which, among other things, will give the same radar response as a heavy bomber. The idea is that it should be dropped from S.A.C. bombers as they approach their targets, to confuse the enemy defences. The guidance system is by Summers Gyroscope.

Following extensive captive and glide tests, Quails were launched last autumn from both B-52s and B-47s, with complete success.

Rascal (GAM-63A)

U.S. air-to-surface stand-off bomb. In service

As a result of the rapid development of more advanced weapon systems, the U.S.A.F. terminated the Rascal programme last November, but the missile remains in service with DB-47E Stratojet units of S.A.C. It was developed by Bell's Special Weapons Division, under prime contracts going back to 1952, and was first delivered to an operational squadron in October, 1957.

The Rascal has a tail-first aeroplane configuration, its control surfaces comprising elevators on the fore-planes, upper and lower rudders at the nose, and ailerons on the trailing-edges of the rear-mounted wings. It is powered by a Bell liquid-propellent rocket engine with three chambers, each of 4,000-lb. s.t. and capable of being fired individually or together.

Early rounds had radio-command guidance, but a Bell Avionics inertial system was specified for the production version. A nuclear warhead is fitted, and Rascal incorporates electronic countermeasures equipment.

Length, 31 ft. 11½ in.; span of wings, 16 ft. 8½ in.; launching weight, approx. 13,500 lb.; speed, approx. Mach 1.5 at 85,000 ft.; range over 75 miles.

Robot 304

Swedish air-to-surface tactical missile. In production

Developed by the Robotbyran (Guided Weapons Bureau) of the Royal Swedish Air Board, the Robot 304 is a powered bomb for use against targets at sea. Its evolution began in 1950 and the first complete missile was fired from a Saab J-29 fighter in February, 1955. Production rounds will be delivered this year to four attack wings of the R.S.A.F., whose A-32A Lansens will carry one 304 under each wing.

The Robot 304 is a tail-first aircraft, with cruciform control surfaces on its nose and rear-mounted delta wings, with a fixed fin at each wing-tip. The powerplant is a solid-propellent rocket motor, and guidance—described as being suitable for all-weather use—is by radio-command from the launching aircraft, with the assistance of wing-tip tracking flares.

Length, 14 ft. 9 in.; diameter, 1 ft. 7¼ in.; span of wings, 6 ft. 8 in.; firing weight, approx. 1,200 lb.; speed (estimated), Mach 0.95; range (estimated), 3 miles.

Wag Tail

U.S. air-to-surface tactical missile. In research phase

Under a research and development contract placed in September, 1956, the Aeronautical Division of the Minneapolis-Honeywell Regulator Co. is developing for the U.S.A.F. an air-launched solid-propellent close-support missile named Wag Tail. Nothing else is known officially about this weapon, but a U.S. report has claimed that, after release by an aircraft flying at supersonic speed at ground level, it will be slowed by retro-rockets to give the aircraft time to get away before the sustainer motor fires and thrusts Wag Tail into its target. Guidance will be by a simple gyro-reference system.

White Lance

U.S. air-launched tactical missile. Under development

White Lance is the name given to a version of the Bullpup (*q.v.*) with improved guidance, which is being developed by Martin's Orlando Division for the U.S.A.F. Tactical Air Command. It will be able to carry alternative nuclear or high-explosive warheads.

Surface-to-air Missiles

Bloodhound

British anti-aircraft guided weapon. In service

One of the most advanced surface-to-air missile systems in the World, Bloodhound is already in service with No. 264 Squadron of R.A.F. Fighter Command at North Coates, Lincs, with other units soon to follow, and has been chosen as Sweden's standard anti-aircraft guided weapon.

Although a shorter-range weapon than Bomarc, Bloodhound has much in common with this U.S. missile, in that it has an aeroplane configuration and is ramjet-powered by two 16-in. Bristol Siddeley Thors. Its construction follows normal aircraft practice, in light alloy, and it is controlled in flight by movement of its pivoted wings, either differentially or together.

The airframe is manufactured by Bristol and the semi-active radar homing guidance system by Ferranti. The present very powerful high-explosive warhead will be replaced eventually by a nuclear warhead.

In operation, an approaching aircraft is detected first by a high-powered Metropolitan-Vickers tactical radar serving a complete Bloodhound wing. At a predetermined range, it is passed on to a chosen fire-unit, whose B.T.H. Sting Ray target-illuminating radar locks on to it, at the same time turning the Bloodhound's 45° launcher so that the weapon is aimed towards the target.

At the right moment to ensure a theoretically perfect interception, the Bloodhound is launched with the aid of four jettisonable solid-propellent boosters and uses signals from Sting Ray reflected from the target to home on the source of the reflections. As each Bloodhound is tuned to its individual illuminating radar, there is no limit to the number of rounds that can be fired at once.

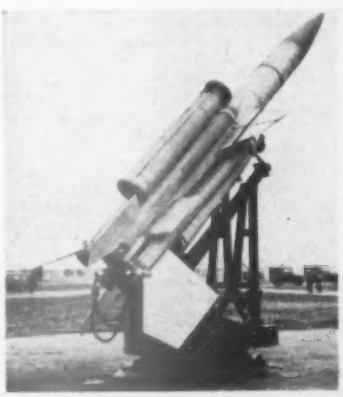
The present version of the missile will be followed by more advanced models, and Bristol Siddeley already have available the 18-in. BRJ-801 ramjet to power them. The ultimate possibilities of Bloodhound were indicated last year when the Minister of Supply commented that longer-range versions under development included a possible anti-missile missile.

Length (with boosters), 25 ft. 3 in.; diameter, 1 ft. 9 in.; span of wings, 9 ft. 3 in.; weight and performance secret, but slant range is probably at least 60 miles.

Bomarc (IM-99)

U.S. long-range anti-aircraft guided weapon. In service

Nearest thing yet to a true pilotless interceptor, Bomarc is the only area-defence anti-aircraft guided weapon known to be in service anywhere in the World, with a range of more than



Bristol Ferranti Bloodhounds are in service with the R.A.F. at North Coates.

Missiles and Astronautics . . . .

which is produced by Bristol to Pye design and incorporates the jet-deflection control system. Wire-guidance bobbins are carried on the tips of two of the cruciform sheet-metal wings, with tracking flares on the other two. The missile is launched from a lightweight tubular ramp and is controlled visually by means of a thumbstick and 20-lb. control box.

Length, 3 ft.; diameter, 6 in.; span of wings, 2 ft.; firing weight, approx. 80 lb.; performance secret.

S.S.10 (Nord 5203)

French anti-tank missile. In service

Despite its small size, this wire-guided missile is claimed to be capable of penetrating 16 in. of armour-plate. It is also battle-proven, having been used successfully by the Israeli Army during the Sinai campaign of 1956.

Very large numbers have been delivered by Nord-Aviation to the armies of France, Israel, Federal Germany, Sweden and the United States. Production is reported to be at the rate of 500 rounds per month.

The S.S.10 consists simply of a cylindrical metal body, fitted with cruciform wings and an 11-lb. hollow-charge warhead. It is powered by a solid-propellent motor, so designed that it burns initially at high thrust to serve as a booster.

Wire-guidance on a line-of-sight flight path is achieved by means of a small joystick-type control, which actuates spoilers that are inset in the wing trailing-edges. The missile rotates slowly during flight.

Length, 2 ft. 10 in.; diameter, 6½ in.; span of wings, 2 ft. 5½ in.; firing weight, 33 lb.; speed, 185 m.p.h.; range, 5,000 ft.

S.S.11 (Nord 5210)

French anti-tank missile. In service

Larger, heavier and with a higher performance than the S.S.10, the wire-guided Nord-Aviation S.S.11 is intended to be launched from trucks, helicopters and aircraft rather than by infantry. It utilizes most of the proven design features and guidance techniques of the smaller weapon, the main difference being that its flight path is controlled by deflecting the efflux of its rocket-motor instead of by aerodynamic surfaces. The normal warhead is a 13-lb. hollow charge.

The S.S.11 is already in service with the French Army and Navy and is being evaluated in Britain, including firing trials from Twin Pioneer aircraft. Many other countries are likely to adopt it.

Length, 3 ft. 6½ in.; diameter, 6 in.; span of wings, 1 ft. 7 in.; firing weight, 69 lb.; speed, 435 m.p.h.; range, just over 2 miles.

Vigilant

British anti-tank missile. Available for service

Developed by Vickers-Armstrongs as a private venture, under the designation of V.891, this wire-guided missile can be carried and fired easily by one man, yet combines a high degree of accuracy with the ability to penetrate the armour of almost any AFV. It comprises a cylindrical light-alloy body, fitted with a cruciform of plastics wings which span only 11 in. Pneumatically actuated control surfaces are hinged on the wing trailing-edges.

The Vigilant has an I.C.I. two-stage solid-propellent rocket motor and carries a hollow-charge warhead of new design, with retractable contact probe. It can be transported, complete with lightweight tubular launcher, in a waterproof canvas bag, the whole package weighing only some 35 lb.; or in a metal canister which can be used also as a zero-length launcher, in which form the "weapon system" weighs 45 lb.

Guidance is by thumbstick control, the operator following the missile's path visually with the aid of a tracking flare. A single operator can be in charge of a series of dispersed missiles, the firing leads from which need only be connected successively to the thumbstick control unit.

The Vigilant is reported to be one of several types under evaluation by the U.S. Army as a replacement for the now-defunct Aerophysics SSM-A-23 Dart.

Length (probe retracted), 2 ft. 9 in.; diameter, 4½ in.; span of wings, 11 in.; speed, approx. 350 m.p.h.; range, approx. 1 mile.

Air-to-surface Missiles

B.B.10

French air-to-surface stand-off bomb

The B.B.10 was developed by Sud-Aviation for the French Air Force as a stand-off bomb for delivery by the Vautour jet-bomber, but it is not known whether the project is still active. In the form displayed in 1957, it was powered by a smokeless solid-propellent motor and guided by radio command.

Guidance included a small television camera and transmitter in the missile, by means of which the controller in the launching aircraft could "see" the target through a window in the missile's nose and so ensure accuracy of attack over a considerable range. The warhead comprised a high-explosive charge of some 400 lb.

Length, 11 ft.; span of tail-fins, 2 ft. 8 in.; firing weight, 900 lb. (These data are approximate.)

Blue Steel

British air-to-surface stand-off bomb. Under development

Avro's Blue Steel is intended as the primary armament of the Vulcan and Victor bombers, which will carry it partly enclosed in the bomb-bay.

Blue Steel has a tail-first aeroplane configuration, and is controlled by pivoted delta foreplanes and inboard ailerons on its rear-mounted delta wings. The ventral fin folds to provide ground clearance for take-off.

Guidance will be by an inertial system developed by Elliott Bros. (London), Ltd., in conjunction with the M.o.S. and R.A.E. No further details have been released officially, but the powerplant is reported to be, initially, a de Havilland Double Spectre twin-chamber liquid-propellent rocket engine, running on H.T.P. and kerosene and giving a total of some 16,000-lb. s.t.

An Avro executive in Australia stated last year that Blue Steel would be flight-tested at Woomera during 1959 from a Vulcan, and that it was intended to cruise at supersonic speed at heights up to 60,000 ft., after release 400 miles from the target. Flight tests from a Valiant are believed to have been under way for some months.

Length, approx. 35 ft.; span of wings, approx. 16 ft.; weight and performance secret.

Bullpup (ASM-N-7)

U.S. air-launched tactical missile. In service

Produced by Martin's Orlando Division, Bullpup is a powerful guided bomb of extreme simplicity. It consists of a cylindrical body, housing any one of a variety of 250-lb. high-explosive warheads, and is powered by a solid-propellent rocket developed by Allegany Ballistics Lab. and produced by Aerojet. Guidance is by radio-command from the launching aircraft, via pivoted cruciform foreplanes, the pilot keeping the missile in sight by means of tracking flares.

Production for the U.S. Navy and Marine Corps is reported to be at the rate of some 600 rounds per month.

The missile is small enough for aircraft like the FJ-4B Fury to carry six on underwing pylons. An improved version known as White Lance (*q.v.*) is under development for the U.S.A.F.

Length, 11 ft. 2 in.; diameter, 12 in.; span of wings 3 ft. 1 in.; firing weight, 540 lb.; speed, Mach 1.8; range up to 5 miles.

Corvus

U.S. air-launched tactical missile. Under development

Under development by Temco since January, 1957, for the U.S. Navy, Corvus is primarily an air-to-surface stand-off missile for use in penetrating heavily-defended areas and against surface ships. Reports indicate that it may also be used in a countermeasures rôle, to home on enemy radar and missile sites, over ranges up to 50 miles.

Corvus is powered by a Reaction Motors Patriot liquid-propellent rocket engine and will have a guidance system manufactured by the Texas Instrument Co. and W. L. Maxson Corp.

Crossbow (GAM-67A)

U.S. air-launched bomber-defence missile

Crossbow is, or was, a countermeasures weapon, intended to be launched from U.S.A.F. strategic bombers and to home on enemy radar and missile sites. It was under development by Radioplane a year ago, with a Westinghouse J81 (Rolls-Royce Soar) turbojet and Bendix-Pacific telemetering equipment for evaluation trials at Holloman A.F.B.; it may have been dropped.

Hound Dog (GAM-77)

U.S. air-to-surface stand-off bomb. Under development

The U.S.A.F. pins great faith on this slender weapon which, in partnership with the Quail decoy missile, should maintain the deterrent power of the B-52G Stratofortress until the supersonic B-70 Valkyrie is ready for service in the mid-sixties. Prime contractor is North

American's Missile Division, under contracts dating back to 1957. A production order was placed last November, with first deliveries of the fully developed weapon scheduled for 1960.

In brief, Hound Dog has a tail-first aeroplane configuration, with a 7,500-lb. s.t. Pratt & Whitney J52 turbojet in a pod under its body. Guidance is by a North American Autonetics inertial system.

One of two alternative payloads can be carried. The first, covered by the weapon system designation WS-131B, consists of a thermonuclear warhead of very high yield. The second, under WS-132A, is reported to comprise countermeasures equipment.

Length, approx. 40 ft.; span of wings, approx. 13 ft.; speed, approx. Mach 1.5; range, approx. 350 miles.

Petrel

U.S. air-to-underwater tactical missile. In service

Although now operational only with the U.S. Naval Reserve, Petrel has been for several years the most reliable and efficient airborne anti-shipping weapon available to American maritime reconnaissance squadrons. Developed in 1949-51 by the National Bureau of Standards and produced by the Fairchild Guided Missiles Division, it consists of a standard Mk. 13 torpedo fitted with underwater radar homing and a jettisonable airframe "package" including a 1,000-lb. s.t. J44 turbojet.

It is launched from beneath the wings of Neptune and Marlin aircraft.

Length, 24 ft.; span of wings, 13 ft.; launching weight, 3,800 lb.; speed, Mach 0.7; range, 5 miles.

Quail (GAM-72)

U.S. air-launched bomber-defence missile. Under development

Classed as an air-launched diversionary missile, Quail has been developed by McDonnell for the U.S.A.F. Strategic Air Command. It consists of a small tailless aircraft made of glass-fibre and powered by a General Electric J85 turbojet of around 2,500-lb. s.t.

Payload comprises electronic countermeasures equipment produced by Ramo-Wooldridge, which, among other things, will give the same radar response as a heavy bomber. The idea is that it should be dropped from S.A.C. bombers as they approach their targets, to confuse the enemy defences. The guidance system is by Summers Gyroscope.

Following extensive captive and glide tests, Quails were launched last autumn from both B-52s and B-47s, with complete success.

Rascal (GAM-63A)

U.S. air-to-surface stand-off bomb. In service

As a result of the rapid development of more advanced weapon systems, the U.S.A.F. terminated the Rascal programme last November, but the missile remains in service with DB-47E Stratojet units of S.A.C. It was developed by Bell's Special Weapons Division, under prime contracts going back to 1952, and was first delivered to an operational squadron in October, 1957.

The Rascal has a tail-first aeroplane configuration, its control surfaces comprising elevators on the fore-planes, upper and lower rudders at the nose, and ailerons on the trailing-edges of the rear-mounted wings. It is powered by a Bell liquid-propellent rocket engine with three chambers, each of 4,000-lb. s.t. and capable of being fired individually or together.

Early rounds had radio-command guidance, but a Bell Avionics inertial system was specified for the production version. A nuclear warhead is fitted, and Rascal incorporates electronic countermeasures equipment.

Length, 31 ft. 11½ in.; span of wings, 16 ft. 8½ in.; launching weight, approx. 13,500 lb.; speed, approx. Mach 1.5 at 85,000 ft.; range over 75 miles.

Robot 304

Swedish air-to-surface tactical missile. In production

Developed by the Robotbyran (Guided Weapons Bureau) of the Royal Swedish Air Board, the Robot 304 is a powered bomb for use against targets at sea. Its evolution began in 1950 and the first complete missile was fired from a Saab J-29 fighter in February, 1955. Production rounds will be delivered this year to four attack wings of the R.S.A.F., whose A-32A Lansens will carry one 304 under each wing.

The Robot 304 is a tail-first aircraft, with cruciform control surfaces on its nose and rear-mounted delta wings, with a fixed fin at each wing-tip. The powerplant is a solid-propellent rocket motor, and guidance—described as being suitable for all-weather use—is by radio-command from the launching aircraft, with the assistance of wing-tip tracking flares.

Length, 14 ft. 9 in.; diameter, 1 ft. 7½ in.; span of wings, 6 ft. 8 in.; firing weight, approx. 1,200 lb.; speed (estimated), Mach 0.95; range (estimated), 3 miles.

Wag Tail

U.S. air-to-surface tactical missile. In research phase

Under a research and development contract placed in September, 1956, the Aeronautical Division of the Minneapolis-Honeywell Regulator Co. is developing for the U.S.A.F. an air-launched solid-propellent close-support missile named Wag Tail. Nothing else is known officially about this weapon, but a U.S. report has claimed that, after release by an aircraft flying at supersonic speed at ground level, it will be slowed by retro-rockets to give the aircraft time to get away before the sustainer motor fires and thrusts Wag Tail into its target. Guidance will be by a simple gyro-reference system.

White Lance

U.S. air-launched tactical missile. Under development

White Lance is the name given to a version of the Bullpup (*q.v.*) with improved guidance, which is being developed by Martin's Orlando Division for the U.S.A.F. Tactical Air Command. It will be able to carry alternative nuclear or high-explosive warheads.

Surface-to-air Missiles

Bloodhound

British anti-aircraft guided weapon. In service

One of the most advanced surface-to-air missile systems in the World, Bloodhound is already in service with No. 264 Squadron of R.A.F. Fighter Command at North Coates, Lincs, with other units soon to follow, and has been chosen as Sweden's standard anti-aircraft guided weapon.

Although a shorter-range weapon than Bomarc, Bloodhound has much in common with this U.S. missile, in that it has an aeroplane configuration and is ramjet-powered by two 16-in. Bristol Siddeley Thors. Its construction follows normal aircraft practice, in light alloy, and it is controlled in flight by movement of its pivoted wings, either differentially or together.

The airframe is manufactured by Bristol and the semi-active radar homing guidance system by Ferranti. The present very powerful high-explosive warhead will be replaced eventually by a nuclear warhead.

In operation, an approaching aircraft is detected first by a high-powered Metropolitan-Vickers tactical radar serving a complete Bloodhound wing. At a predetermined range, it is passed on to a chosen fire-unit, whose B.T.H. Sting Ray target-illuminating radar locks on to it, at the same time turning the Bloodhound's 45° launcher so that the weapon is aimed towards the target.

At the right moment to ensure a theoretically perfect interception, the Bloodhound is launched with the aid of four jettisonable solid-propellent boosters and uses signals from Sting Ray reflected from the target to home on the source of the reflections. As each Bloodhound is tuned to its individual illuminating radar, there is no limit to the number of rounds that can be fired at once.

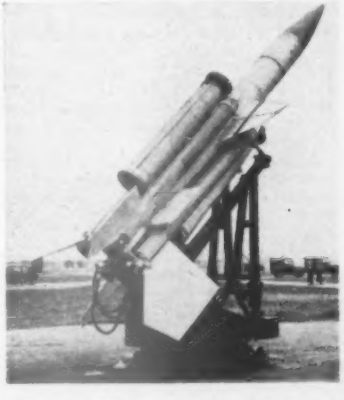
The present version of the missile will be followed by more advanced models, and Bristol Siddeley already have available the 18-in. BRJ-801 ramjet to power them. The ultimate possibilities of Bloodhound were indicated last year when the Minister of Supply commented that longer-range versions under development included a possible anti-missile missile.

Length (with boosters), 25 ft. 3 in.; diameter, 1 ft. 9 in.; span of wings, 9 ft. 3 in.; weight and performance secret, but slant range is probably at least 60 miles.

Bomarc (IM-99)

U.S. long-range anti-aircraft guided weapon. In service

Nearest thing yet to a true pilotless interceptor, Bomarc is the only area-defence anti-aircraft guided weapon known to be in service anywhere in the World, with a range of more than



Bristol Ferranti Bloodhounds are in service with the R.A.F. at North Coates.

Missiles and Astronautics . . . .

200 miles in its initial form. It has been under development by Boeing's Pilotless Aircraft Division since 1949.

Bomarc is "pure aeroplane" with a conventional monoplane configuration, fitted with rotating wing-tip ailerons, an all-moving tailplane and a fin-tip rudder.

The propulsion system of the initial IM-99A comprises two 28-in. Marquardt RJ43-MA-3 ramjets (each 11,500-lb. s.t.) carried on under-fuselage pylons, with an internal 35,000-lb. s.t. Aerojet gimballed liquid-propellent (nitric acid and kerosene) booster to accelerate the weapon to a speed where its ramjets become effective. Guidance equipment by Westinghouse uses radio-command signals from the SAGE system to bring the missile to a point from where its own active radar homing can take over.

At operational units, Bomarcs will be stored on their ramps inside individual shelters at a state of readiness that will permit firing within two minutes of an alert being given. Launching is vertical and can be effected entirely automatically and remotely from any SAGE control centre.

The first production IM-99A was delivered in December, 1957, and the first four U.S.A.F. Air Defense Command units to equip with the weapon will be at Dow, McGuire, Otis and Suffolk County A.F.B.s, in the north-eastern States. Each will have 24 or 56 Bomarcs and the first units will become operational late this year.

Boeing have an extensive development programme for Bomarc and the next version to appear will be the IM-99B with more-powerful Marquardt RJ43-MA-7 ramjets and a solid-propellent internal booster. The range of this version will be increased to some 400 miles.

Length, 47 ft.; diameter, 2 ft. 11 in.; span of wings, 18 ft. 2 in.; firing weight, approx. 15,000 lb.; speed, over Mach 2.5 at above 60,000 ft.; range, over 200 miles. (These data apply to the IM-99A.)

Hawk (M3)

U.S. low-altitude anti-aircraft missile

Hawk was designed to plug the dangerous gap in America's defences caused by the inability of missiles of the Nike family to deal with low-flying raiders. To this end, it utilizes a special semi-active homing guidance system based on the use of continuous-wave monopulse radar. This can sort out a moving target from a maze of stationary objects on the ground, producing an echo from only the target.

Raytheon, who developed the guidance equipment, are prime contractors for the weapon. The airframe is manufactured by Norair (Northrop) and Temco, and Aerojet are responsible for providing the solid-propellent motor, of which the first part burns more rapidly than the second to act as a booster. Control is by means of elevons hinged to the trailing-edges of the cast-steel cruciform wings, and a variety of high-explosive warheads can be fitted.

Hawk was to become operational with U.S. Army units in the United States and overseas this year, and production in Europe for NATO countries was also likely. However, the Joint Chiefs of Staff Committee decided last month not to utilize it for North American defence and its future is uncertain.

Length, 16 ft. 4 in.; diameter, 1 ft. 2 in.; span of wings, 4 ft.; firing weight, 1,285 lb.; speed at burn-out, above Mach 2.8; slant range, up to 22 miles.

Masurca

French ship-based anti-aircraft missile. Under development

According to an official statement, Masurca is destined to be the chief defensive weapon of French naval craft against aircraft of very high performance. No details are available, but components have been under test for at least two years on a ramp-launched research and training missile named Maruca, which has a conventional aeroplane configuration. Both Masurca and Maruca are products of the Direction des Etudes et Fabrications d'Armement (D.E.F.A.).

Mauler

U.S. battlefield anti-aircraft missile. Under development

Existence of a programme to develop a combat area anti-aircraft missile known as Mauler was revealed only five months ago. Few details are available except that it will be a lightweight infra-red homing missile for protection against enemy close-support aircraft and will be issued on the basis of six missiles per firing unit.

MTG-CI-57 and -58

Italian anti-aircraft missiles. In service

MTG-CI-57 is the designation of the Swiss Contraves-Oerlikon RSC-57 anti-aircraft training missile as built under licence in Italy by Contraves Italiana since 1956. It is in standard use on the Italian Air Force firing range in Sardinia. The operational version of the same missile, corresponding with the Contraves-Oerlikon RSD-58, is designated MTG-CI-58. Descriptions of both versions will be found under their Swiss designations.

Nike-Ajax (SAM-A-7)

U.S. anti-aircraft missile. In service

First anti-aircraft guided missile to enter service with the U.S. Army, in 1953, Nike-Ajax has since formed a major component of North America's overall air defences, being integrated with piloted interceptor units through the SAGE (semi-automatic ground environment) electronic warning and control system.

Altogether, some 16,000 production rounds have been delivered, for service also in Greenland, Alaska, Germany and other overseas areas where U.S. Forces are stationed. Continuous servicing and modification programmes are keeping these missiles operational, but gradual replacement by the improved Nike-Hercules has been under way for some months.

Nike-Ajax was developed by the U.S. Army with Bell Telephone Lab. as the development contractor and Western Electric and Douglas the prime production contractors, under a programme started in 1945.

A two-stage missile, Nike-Ajax has a 2,600-lb. s.t. Bell Aircraft (originally Aerojet) liquid-propellent sustainer, burning nitric acid and kerosene, and a tandem-mounted solid-propellent separable booster by the Hercules Powder Co.

Guidance, by Western Electric, is of the radar command type. Very extensive ground equipment tracks both missile and target continuously and, at the appropriate time, detonates the high-explosive multiple warheads by a modified signal. The missile is controlled in flight by means of its fore-planes.

At sites manned by 73 missile battalions, around major U.S. cities and military targets, many of the weapons are stored underground on their launchers, with 12 launchers and about 100 officers and men per site. However, all components of the system are described as being completely mobile and some sites are not so firmly entrenched.

Length, with booster, 35 ft. 5 in.; without booster, 21 ft.; diameter 12 in.; span of wings, 5 ft. 3 in.; firing weight, 2,100 lb.; speed at burn-out, Mach 2.3; slant range, up to 25 miles.

Nike-Hercules (SAM-A-25)

U.S. anti-aircraft missile. In service

Developed and produced by the same team as Nike-Ajax, the U.S. Army's Nike-Hercules is a vastly improved and more manœuvrable weapon which can be integrated into batteries of the earlier missile after modification of the ground handling, firing and control equipment. Conversion of the launching sites has been under way for some time and Nike-Hercules was operational at eight units in the United States, and in Formosa, by November of last year. It is hoped to replace all Nike-Ajax missiles by the middle of this year, and eventually missile protection will be extended to many additional cities and S.A.C. bases.

Although Nike-Hercules is much larger and heavier than its predecessor, the switch to a Thiokol solid-propellent sustainer motor makes it relatively inexpensive and simple.

The small fore-planes of Nike-Ajax have given way to elevons hinged on the trailing-edges of the long-chord delta wings, and the Western Electric radar-command guidance system has been greatly improved. In particular it is effective over the much longer range of Nike-Hercules, which is intended to intercept air-to-surface missiles and to destroy piloted bombers.

The tandem booster for Nike-Hercules comprises a cluster of four Nike-Ajax boosters, but an improved design is reported to be under development by Thiokol. Other planned changes include the provision of alternative nuclear or high-explosive warheads and the addition of terminal radar homing.

Length, with booster, 41 ft. 6 in.; without booster, 27 ft.; span of wings, 8 ft. 9 in.; firing weight, approx. 10,000 lb.; burn-out speed, Mach 3.35; slant range, 75 miles.

Nike-Zeus

U.S. anti-missile missile. Under development

Nike-Zeus is the U.S. Army's anti-missile missile, and the only active American project of this kind since the U.S.A.F.'s competing Wizard programme was more or less suspended last year. Its development has been under way since 1955 by the Western Electric-Bell Telephone Lab.-Douglas team which produced the Nike-Ajax and the Nike-Hercules.

Unconfirmed reports say that it will be launched from the same sites as the present weapons and will be fitted into the SAGE electronic network as just a further stage in the Nike programme.

Key to the success of Nike-Zeus is, of course, the effectiveness of the radar equipment used to detect the launching of the ICBMs that will be its principal targets. Initial warning of a firing will be given by three surveillance radars of

(*Continued on page 479*)

de Havilland Otter Amphibians For Search and Rescue

Emergency evacuation from a tiny lake in the wilderness to a waiting ambulance hundreds of miles away is a simple task for the Otter Amphibian.

R.C.A.F. Search and Rescue Otter Amphibians are playing a dramatic role in civil and military operations within our Northern Air Defence areas.

THE *Otter*

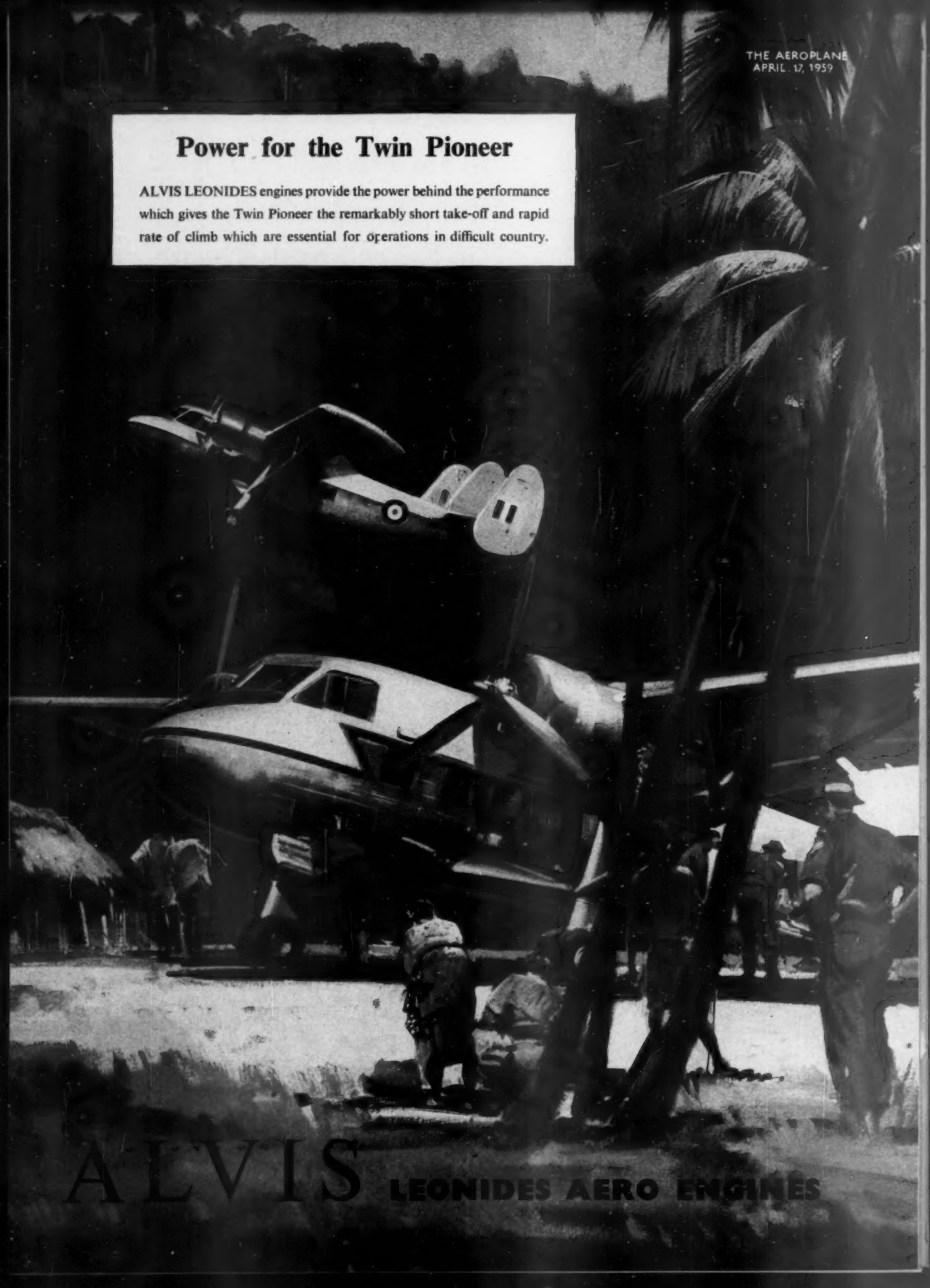
58-7

Designed and built by

THE DE HAVILLAND AIRCRAFT OF CANADA LIMITED

DOWNSVIEW, ONTARIO, CANADA

Western Sales and Service: Municipal Airport, Edmonton, Alta. Pacific Coast Sales and Service: Vancouver, B.C.



Power for the Twin Pioneer

ALVIS LEONIDES engines provide the power behind the performance which gives the Twin Pioneer the remarkably short take-off and rapid rate of climb which are essential for operations in difficult country.

ALVIS LEONIDES AERO ENGINES

Missiles and Astronautics . . . .

(*Continued from page 478*)

R.C.A. manufacture, which will be sited in the Arctic. The target will then be passed on to a Sperry tracking radar, which will lock on to the missile and predict its trajectory quickly and accurately enough to make possible the launching of a Nike-Zeus on a course designed to achieve interception over a slant range of 100 miles.

The missile will have some form of terminal homing guidance, developed by Ryan, and it has been suggested that this might home on electro-magnetic disturbances caused by the re-entry into the atmosphere of the ICBM warhead.

It has been reported unofficially that Nike-Zeus is very like a scaled-up Nike-Hercules in configuration, with a Grand Central Rocket Co. solid-propellent sustainer and a 450,000-lb. s.t. solid-propellent booster by Thiokol. The U.S. Army hopes to have it operational by the mid-sixties, and research and development appropriations for it were increased this year.

Parca

French anti-aircraft missile. In service

The version of Parca (Projectile Autopropulsé Radioguidé Contre Avions) now serving in small numbers with the French Army does not have a high enough performance to be wholly effective against modern jet-bombers. It is, however, proving useful as a development and training weapon, and is still being fired at the Centre Interarmées d'Essais d'Engins Speciaux at Colomb-Béchar in the Sahara.

Powered by an S.E.P.R. solid-propellent sustainer, Parca is a tail-first missile with a radar command guidance system which uses two separate "dishes" to track the missile and target. It is launched from a mobile ramp with the aid of four wrapped and jettisonable S.E.P.R. solid-propellent boosters and is controlled by means of its pivoted fore-planes.

Length, with boosters, 18 ft.; without boosters, 16 ft. 8 in.; span of wings, 5 ft. 3 in.; firing weight, approx. 2,200 lb.; speed at burn-out, Mach 1.7; ceiling, over 65,000 ft.

Redeye

U.S. battlefield anti-aircraft missile. Under development

At present in only an early design study stage, Redeye is intended to provide U.S. infantry units with an effective man-portable defence against low-flying aircraft and helicopters. It will be little more than a surface-to-air bazooka, with an infra-red homing head.

RSC-57 and RSD-58

Swiss anti-aircraft missiles. In service

Developed as a private venture by the Contraves and Oerlikon companies, the RSD-58 is the current production version of a highly successful anti-aircraft missile which possesses the unique quality of being available "off the shelf." The RSC-57 is similar, except that it has a parachute-recovery system for use as a training missile, in place of the proximity-fused 88-lb. high-explosive warhead of the operational version.

The RSD-58 has a conventional cruciform-wings-and-tail configuration, with bonded light-alloy body and wings of sandwich construction. It is controlled via the tail surfaces, and the wings are shifted axially to compensate for C.G. changes as propellents burn.

Propulsion is by a single 2,200-lb. s.t. liquid-propellent sustainer, with gimballed chamber for control at low speeds. No booster is fitted. The missile is fired from a twin launcher at any angle between 10° and 90°, with beam-riding guidance, and it is claimed that a six-launcher battery could offer a rate of fire of 12 rounds per minute.

Development has continued steadily since 1947 with extensive trial firings in Switzerland and France in 1950-51, evaluation of a batch of 25 at Holloman AFB, New Mexico, in 1952, further test firings in Switzerland in 1954, and continuous service at the Italian firing range in Sardinia for the past three years.

Length, 20 ft.; diameter, 1 ft. 4 in.; span of wings, 4 ft. 5 in.; firing weight, RSC-57 845 lb., RSD-58 890 lb., speed at burn-out, RSC-57 Mach 1.8, RSD-58 Mach 2.4; ceiling, RSC-57 40,000 ft., RSD-58 66,000 ft.; slant range RSC-57 10 miles, RSD-58 19 miles.

Latest photographs of the Armstrong Whitworth Seaslug surface-to-air weapon for the Royal Navy show it with blunt nosed boosters.

Seacat and Tigercat

British ship-launched low-altitude anti-aircraft missile. Under development

Intended to replace the 40-mm. gun, which has been the standard close-range anti-aircraft weapon of the Royal Navy for many years, the Short Seacat will be a small and highly manœuvrable missile powered by a solid-propellent motor. Deliveries are expected to begin in the early 1960s, and a land-based variant known as Tigercat is being studied for Army use.

No further details have been released, but the Short SX-A5 test vehicle for preliminary research on the new weapon was first exhibited at the 1957 S.B.A.C. Display. As the Seacat may be on the same lines, it seems worth recording that the SX-A5 is a two-stage solid-propellent missile controlled by cruciform pivoted wings and with radio-command guidance.

Length, 6 ft. 5 in.; diameter, 9½ in.; span of wings, 2 ft. 7 in.; weight and performance secret. (These data apply to the SX-A5.)

Seaslug

British ship-launched anti-aircraft missile. Under development

Seaslug is described officially as "the medium weapon which is designed to engage any enemy bomber which evades the fighter defences of the Fleet and to do so at any height at which modern aircraft are capable of flying." It will arm the Royal Navy's four new "Hampshire"-class fleet-escort G.W. ships and has proved itself outstandingly efficient in trials on H.M.S. "Girdle Ness." During a series of more than 100 firings in the Mediterranean last year the first of two Seaslugs fired as a salvo destroyed the target aircraft, after which the second made a direct hit on the largest piece of the wreckage.

Armstrong Whitworth are prime contractors for Seaslug, which has the classical British cruciform-wings-and-tail configuration, with four jettisonable solid-propellent boosters wrapped around its forebody. This removes the need for stabilizing fins on the boosters and leads to a considerable reduction in bulk, which is an important consideration for missiles stowed on board ship. The boosters lack pointed nose fairings for the same reason.

Although early models had liquid-propellent rocket engines, Seaslug now has an I.C.I. solid-propellent sustainer. The radar guidance system is by G.E.C. and the control system by Sperry. The weapon is fired from a triple launcher, fed automatically from a large magazine below decks. A high-explosive warhead will be fitted initially.

Length, approx. 20 ft.; span of wings, approx 5 ft. 3 in.; weight and performance secret.

Soviet Missile M-2 (?)

Anti-aircraft missile. Probably in service

Shown publicly during the military parade through Moscow in November, 1957, the two-stage surface-to-air weapon reportedly designated M-2 must be regarded as an early missile, with more advanced designs almost certainly in production. It bears a certain resemblance to the Nike-Ajax and has been assumed to have much the same sort of performance.

Externally evident features, including the small blade aerials on the nose, give the impression of its utilizing a beam-riding or radar-command guidance system, and it is assumed to have a liquid-propellent sustainer. An interesting point is that the tandem solid-propellent booster is attached via a hollow casting, in such a way that sustainer and booster can be fired together at take-off.

The following data are estimated:

Length, with booster, 25 ft.; without booster, 19 ft.; diameter, 1 ft. 8 in.; span of wings, 6 ft.; firing weight, 2,500 lb.; slant range, up to 20 miles.

Talos (SAM-N-6, 6b, 6bw, 6c and 6ci)

U.S. ship-launched anti-aircraft missile. In service

Talos is primarily a ship-based surface-to-air weapon, powered by a ramjet engine which is stated to develop 40,000 h.p. and with a surprisingly great slant range of more than 65 miles. Ramp-launched with the aid of a tandem solid-propellent booster, it utilizes beam-riding guidance during most of its flight, but has a semi-active terminal homing system. There is a choice of nuclear or high-explosive warheads with proximity fusing, the nuclear version dispensing with the terminal homing equipment.

Bendix Products Division—Missiles are prime contractors for the weapon system. Bendix were called in soon after the start of the project and have been responsible for the entire ramjet development. Talos airframes, with pivoted cruciform wings and fixed tail-fins, are manufactured by McDonnell.

Flight testing at White Sands Proving Ground, New Mexico, has proved successful, but the weapon system is extremely complicated and expensive.

Missiles and Astronautics . . . .

which is probably why the U.S.A.F. and Army are no longer interested in it. At present the light cruiser "Galveston" is the only U.S. naval vessel armed with Talos, but it will equip five new guided-missile cruisers as well as the nuclear-powered cruiser "Long Beach."

Length, with booster, 30 ft.; without booster, 20 ft.; diameter, 2 ft. 6 in.; span of wings, 8 ft. 6 in.; firing weight, less booster, 3,000 lb.; slant range, over 65 miles.

Tartar

U.S. ship-launched anti-aircraft missile. In production

Described as a junior version of the Terrier, Tartar is a two-stage solid-propellent surface-to-air missile small enough to go into destroyers and to be used as secondary armament on larger ships. Yet it has a higher performance than the version of the Terrier now operational with the U.S. Navy. This has been made possible by recent advances in solid-propellent know-how, and the U.S. Navy plans to utilize Tartar on the heavy cruisers "Chicago," "Albany" and "Fall River" and 18 destroyers, in place of weapons such as the conventional 5-in. gun.

Convair is prime contractor for Tartar, with motors reportedly by Aerojet and a beam-riding guidance system in which Convair, Sperry and Ford Instrument all have a hand. Pilot production began at Convair's Pomona Division in March, 1958, to provide rounds for test and evaluation, and it is hoped to have the weapon in service next year.

Terrier (SAM-N-7)

U.S. ship-launched anti-aircraft missile. In service

An offshoot of the Bumblebee programme conducted by the Applied Physics Lab. of John Hopkins University, Terrier is an all-weather surface-to-air missile which was fired for the first time in 1954 and has been operational for some time on board the U.S. Navy cruisers "Boston" and "Canberra," and the destroyer "Gyatt." It also equips the 1st Medium Anti-aircraft Missile Battalion of the U.S. Marine Corps, stationed ashore at Twentynine Palms, Calif., and is scheduled to arm two "Forrestal"-class carriers, four more cruisers (one of them the nuclear-powered "Long Beach"), 20 frigates (one of them nuclear-powered) and one nuclear-powered carrier.

Terrier is a straightforward two-stage solid-propellent missile, for which the sustainer and tandem booster are supplied by Allegany Ballistics Lab. It is launched from a twin mounting and utilizes a beam-riding guidance system, which controls its direction of flight via the pivoted cruciform wings. The warhead is of the high-explosive type.

In January of this year it was announced that Convair had received a production order for an advanced version of Terrier with improved guidance and range.

Length, with booster, 25 ft. 5 in.; without booster, 14 ft. 9 in.; firing weight, approx. 2,500 lb.; slant range, 10 miles.

Thunderbird

British anti-aircraft missile. Under development

Under development by the Guided Weapons Division of English Electric since 1950, the Thunderbird was powered originally by a liquid-propellent sustainer, but has since been re-engined with a more attractive solid-propellent motor. It follows the classical British pattern (to which Bloodhound is an exception) with cruciform fixed wings and pivoted tail surfaces, and four jettisonable solid-propellent boosters. Guidance, by Marconi, is of the semi-active homing type and is able to utilize the same B.T.H. Sting Ray target-illuminating radar as Bloodhound.

Firing tests against target aircraft at Aberporth and Woomera have proved very successful, and Thunderbird is in production for the British Army, with acceptance trials currently under way. A parallel production order was placed on behalf of the R.A.F. in 1957, but it is unlikely that Fighter Command will wish to operate the current versions of both Bloodhound and Thunderbird. An advanced version of the latter is under development, making use of the latest progress in solid propellents and guidance technology, and may explain R.A.F. interest in this weapon.

Length, 18 ft. 10½ in.; diameter, 1 ft. 8¾ in.; span of wings, 5 ft. 6¾ in.; weight and performance secret.

The English Electric Thunderbird, is an anti-aircraft weapon for the British Army; here one is on a Kestrel 3-ton fork-lift carrier used to lift it on to the launcher.

TLRM-1

Japanese anti-aircraft missile. Under development

Mitsubishi are building an initial series of four experimental surface-to-air missiles under the designation of TLRM-1, and the first of these was fired successfully at a range near Mount Fuji on June 2 last year. Powered by a liquid-propellent motor, it was launched from a small mobile zero-length ramp. No warhead was fitted.

Length, 10 ft. 9½ in.; firing weight, 558 lb.; performance not available.

TMB-0

Japanese anti-aircraft missile. Under development

Few details of this small surface-to-air weapon are available, except that it has a firing weight of 45 lb. Prime contractor is Mitsubishi, with rocket motor by Fuji Precision Machinery and guidance by Mitsubishi Electrical Machinery.

Air-to-air Missiles

A.A.20 (Nord 5103)

French air-to-air missile. In production

Already built in thousands and fired successfully from most current French interceptors, the A.A.20 is a simple air-to-air and air-to-surface missile sharing many features of another Nord product, the S.S.11 anti-tank weapon. Like the latter, it has a swept-wing tailless configuration and is controlled in flight by deflecting the jet efflux of the sustainer portion of its two-stage solid motor.

Main difference is that it is guided by radio-command signals from the launching fighter, by means of a small joystick unit, with line-of-sight tracking. The signals are coded.

The A.A.20 can be fitted with either a training warhead or a high-explosive type with proximity fuse.

Length, 8 ft. 6½ in.; diameter, 10 in.; span of wings, 2 ft. 7½ in.; firing weight, air-to-air, 295 lb.; air-to-surface, 380 lb.; speed at burn-out, Mach 1.7; range, up to 2½ miles.

C.7

Italian air-to-air missile. Under development

Contraves Italiana are developing in conjunction with the official Centro Razzi a simple air-to-air missile, designated C.7, with infra-red homing guidance. Photographs have been published showing the weapon during flight trials under the wings of an F-86 Sabre interceptor of the Italian Air Force. They indicate that it consists of a lengthy solid-propellent motor tube fitted with a cylindrical fore-body containing the guidance equipment and warhead, low-set wings and fixed cruciform tail-fins. The wings are pivoted to work differentially or together to control the missile in flight.

Length, 7 ft. 11 in.; span of wings, 1 ft. 6 in.; firing weight, 120 lb. (These data are estimated.)

Diamondback

U.S. air-to-air missile. Under development

An improved version of Sidewinder (*q.v.*) is reported to be under development at the Naval Ordnance Test Station, China Lake, Calif., with the name of Diamondback. No details are available, except that the new weapon will offer increased speed and range, and it might well be the missile referred to by the U.S. Navy as Sidewinder-1C.

Eagle

U.S. air-to-air missile. Under development

Prime contractors for this extremely interesting and important long-range air-to-air missile for the U.S. Navy are Bendix Aviation. One of their recent

Beam-riding Terrier surface-to-air missiles are in service with the U.S. Navy; an improved version with terminal homing is being developed.

advertisements implies that it could be launched from comparatively slow turboprop-powered aircraft against high-performance jet-bombers, which confirms reports that the purpose of the Eagle project is to transfer as much as possible of the interception operation from the launching aircraft to the missile. This imposes considerable responsibility on the Bendix Systems Division, who are developing the electronic guidance and fire-control equipment to be carried by the aircraft.

In operation the latter would probably take off from a carrier on standing patrols of long endurance. Its job would be to fly towards an enemy bomber that might be detected and launch Eagle over the longest practicable range—perhaps as much as 50-100 miles from the target. The missile would then home on the bomber, destroying it with a nuclear warhead.

Falcon (GAR-1 and 2)

U.S. air-to-air missile. In service

Development of this remarkably compact air-to-air missile was started by Hughes Aircraft in 1950. It became operational in 1957 and many thousands have since been delivered as primary armament for the F-89 Scorpion, F-101 Voodoo, F-102 Delta Dagger and F-106 Delta Dart interceptors of the U.S.A.F. Air Defense Command.

Falcon has a tail-first configuration with four small fixed stabilizing fins on its nose and control surfaces aft of its long-chord cruciform wings. Its power unit consists of a 6,000-lb. s.t. Thiokol M58-E4 solid-propellent rocket motor; no booster is fitted.

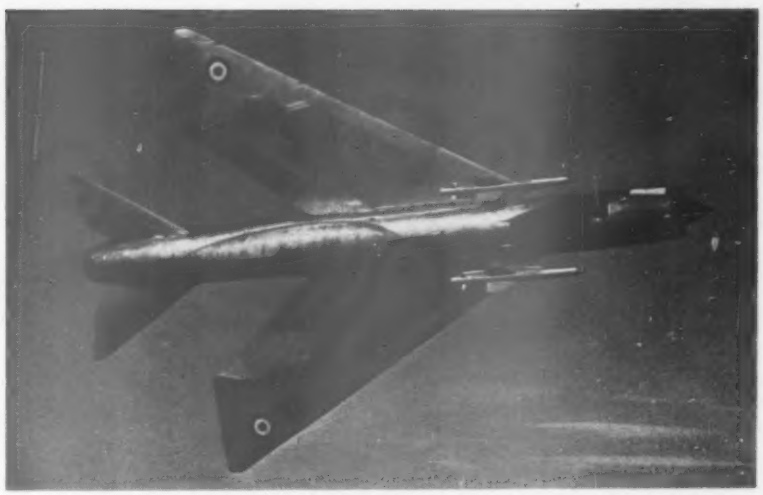
The original production version, designated GAR-1, had a semi-active radar homing system and can be distinguished by the fact that its control surfaces were hinged directly on the wing trailing-edges. To improve performance and manœuvrability at height, the GAR-1D superseded it in production, with an improved motor and a gap between the wing trailing-edges and the control surfaces. This version is now in service side-by-side with the GAR-2A, which is identical except that it employs infra-red homing instead of the semi-active radar system of the 1D.

Firing trials have shown that the GAR-2A is slightly more efficient than the GAR-1D, but infra-red has its limitations in cloud, so U.S.A.F. fighters usually carry a mixed bag of 1Ds and 2As, which is reckoned to guarantee a 90% kill probability.

Even more advanced versions are now being developed under the name of Super Falcon (*q.v.*).

Length, 6 ft. 6 in.; diameter, 6½ in.; span of wings, 1 ft. 8 in.; firing weight, GAR-1D 110 lb., GAR-2A 122 lb.; speed, above Mach 2; range, approx. 5 miles.

The Falcon GAR-1D air-to-air missile which has a semi-active homing system.



Two de Havilland Firestreaks form the standard air-to-air missile armament of the Lightning; they are fuselage mounted on pylons.

Fireflash

British air-to-air missile. In service

Although production has ended, the Fireflash is still in service with No. 1 Guided Weapon Development Squadron of the R.A.F. at Valley, Anglesey, where it has provided valuable training in guided weapon handling and firing from specially equipped Swift F.7 fighters.

First British guided weapon to destroy a target aircraft, Fireflash was developed by Fairey Aviation under a programme dating back to 1949. Its configuration is unique in that the missile itself is an unpowered dart, which is accelerated to cruising speed by two jettisonable 5-in. cordite boosters. A beam-riding guidance system is used, with Plessey receivers in the missile and Ekco radar in the launching aircraft. The high-explosive warhead is fitted with a proximity fuse.

Length, with boosters, 9 ft. 3¾ in.; without boosters, 7 ft. 5 in.; span of wings, 2 ft. 4 in.; firing weight, 300 lb.; speed, over Mach 2.

Firestreak

British air-to-air missile. Entering service

Firestreak will form the primary armament of all three of Britain's "last-generation" all-weather fighters, two being carried by the Lightning and four each by the Javelin Mks. 7 and 8 and the Sea Vixen. All these types mount the associated fire-control radar internally, behind a dielectric fuselage nose-cone; but de Havilland Propellers, prime contractors for the weapon, have developed a packaged unit which can be fitted to almost any fighter to convert it into a Firestreak-carrier. Packs of this kind were carried by the R.A.A.F. Avon-Sabres used for development trials of the weapon at Woomera in Australia.

The design of the Firestreak is straightforward, with fixed cruciform wings and pivoted tail control surfaces carried on a cylindrical body. Power is provided by a solid-propellent sustainer motor, and guidance is by an infra-red homing system, the heat-sensitive cell for which is mounted behind eight optically flat glass nose panels.

De Havilland claim that they have succeeded in making Firestreak practically impervious to infra-red radiation from natural causes, which represents a tremendous achievement. Together with the infra-red proximity fuse, which makes the warhead lethal over a considerable radius, this helps to explain the outstanding success of the overall weapon system, more advanced versions of which are on the way.

Length, 10 ft. 5½ in.; diameter, 8.67 in.; span of wings, 2 ft. 5½ in.; weight and performance secret.

Genie (MB-1)

U.S. unguided air-to-air missile. In service

Genie incorporates an atomic warhead which makes possible the destruction of aircraft over a radius of at least 2,500 ft. from where it is detonated by a proximity fuse. Manufactured by Douglas, it is powered by an Aerojet solid-propellent motor and has no guidance system beyond spin-stabilization and a simple gravity-correction device which actuates the movable fin-tips.

Development of Genie was started in 1955, as soon as a miniaturized nuclear warhead became available, and it was fired for the first time from an F-89J Scorpion over Yucca Flat, Nev., on July 19, 1956. The missile was released at 15,000 ft., after which the pilot of the F-89J had to break away sharply to escape the blast. The missile travelled on for three miles and was detonated by a signal from the ground. Fall-out was negligible.

In service Genie is carried externally by the F-89J, F-101 Voodoo and F-102 Delta Dagger, and internally on the F-106 Delta Dart. In each case it is intended to be fired and detonated automatically by the aircraft's Hughes fire-control radar. As a safety precaution, Genie remains inert in the nuclear sense until it is armed a few seconds before firing.

Length, approx. 8 ft.; diameter of warhead, approx. 1 ft. 3 in.; firing weight and performance secret.

(*Continued on page* 482)

Missiles and Astronautics . . . .

(*Continued from page 481*)

R.510

French air-to-air missile. In service

Specified as a standard weapon for the Vautour IIN, the Matra 510 was put in production after extensive trials on Meteors and Canberras. It has appeared in several forms, but all are basically canard weapons, controlled through movable fore-planes and an under-fuselage rudder.

Guidance is by a unique active homing system. In this, a photo-cell is mounted in the nose behind a small window which gives it a field of vision within a 20° cone. By sensing variations of light and shade it is able to fix the angular co-ordinates of the target. This information is combined electronically with data on the missile's speed and angular acceleration provided by sensing units in the autopilot and the resultant signals are used to actuate the controls.

Initially, the R.510 was powered by a S.E.P.R. liquid-propellent motor, but this has been superseded by a solid-propellent type, in which the first portion develops the greater thrust to function as a booster. A 66-lb. high-explosive warhead is fitted, with proximity fusing. A variant, with beam-riding or semi-active radar homing, designated M.051, has been built in small numbers.

Length, 10 ft. 6 in.; diameter, 11 in.; span of wings, 3 ft. 3½ in.; firing weight, 355 lb.; speed at burn-out, Mach 1.7; range, up to 5 miles.

Robot 321A

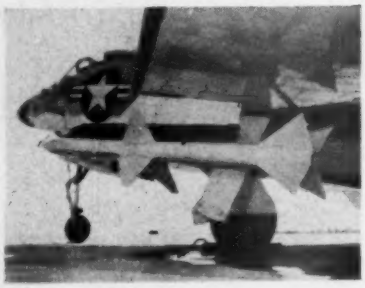
Swedish air-to-air missile. Under development

The Robotbyran (Guided Weapons Bureau) of the Royal Swedish Air Board is known to be developing an air-to-air missile to arm the Saab J35 Draken interceptor. This weapon is reported to bear some resemblance to the tail-first delta-wing Robot 321A test vehicle which was launched on December 20, 1948. If it does, it will be unusually large, for the test vehicle measured 17 ft. 6 in. in length with its jettisonable booster, and had a firing weight of 630 lb.

Sidewinder (AAM-N-7, GAR-8)

U.S. air-to-air missile. In production and service

Developed by the Naval Ordnance Test Station at China Lake, Calif., between 1948 and 1952, Sidewinder has since been produced in enormous numbers by the Philco Corp. and General Electric. It forms the primary armament of carrier-based aircraft of the U.S. Sixth and Seventh Fleets, and has the distinction of being in service also with the U.S.A.F., as wingtip armament on the F-104 Star-fighters of Air Defense Command. In addition, Sidewinders have been adopted by the air forces of Australia, Federal Germany, Japan, Nationalist China, Norway and Sweden, and by the Royal Canadian Navy.



Sparrow III air-to-air missile mounted under the wing of a U.S. Navy Demon.

Main attractions of Sidewinder, apart from its proven accuracy and reliability, are its simplicity and cheapness. Said to contain no more electronic components than the average home radio, it consists of a 75-in.-long solid-propellent motor tube, manufactured by Hercules Power Co., with an infra-red guidance and control package mounted on the front, plus cruciform fore-plane control surfaces and cruciform fixed tail-fins. The warhead contains only 5 lb. of high explosive, with a proximity fuse to make it lethal over a radius of 35 ft.

Sidewinder-armed Sabres of the Nationalist Chinese air force destroyed 14 Red Chinese MiG-17s in a single day last October.

An advanced version of the Sidewinder, known as Sidewinder-1C, is under development and will offer higher speed and greater range capabilities. No details are available, and the following data apply to the current production model.

Length, 9 ft. 5 in.; diameter, 4½ in.; span of fins, 1 ft. 7 in.; firing weight, 155 lb.; speed at burn-out, Mach 2.5; range at sea level, approx. 3,500 ft., at 50,000 ft. over 2 miles.

Sparrow III (AAM-N-6)

U.S. air-to-air missile. In production and service

Development of the Sparrow family of air-to-air missiles for the U.S. Navy began in 1945 as Sperry's Project Hot-Shot. It led first to the beam-riding AAM-N-2 Sparrow I, which was flight tested in 1951 and became operational with the U.S. Atlantic and Western Pacific Fleets five years later. Several thousand were produced by Sperry and many are still in service; but they are being replaced progressively by the much-improved Sparrow III.

Sparrow III has a body of greater diameter than its predecessor and has switched to all-weather semi-active radar homing guidance, designed by its prime contractor, the Raytheon Manufacturing Co. Its Aerojet solid-propellent motor is of greater power than the type fitted in Sparrow I, and it has a bigger warhead than other U.S. air-to-air missiles.

Flight testing from Skyray and Demon aircraft has proved highly successful, and the Sparrow III is now in production to arm current and all future U.S. Navy all-weather fighters, including the new McDonell F4H.

Length, 12 ft.; diameter, 9 in.; span of wings, 3 ft. 3 in.; firing weight, approx. 350 lb.; burn-out speed, over Mach 2.5; range, approx. 5 miles.

Super Falcon (GAR-3)

U.S. air-to-air missile. In production

Although basically similar to the GAR-1 and 2 Falcons, the GAR-3 offers considerably improved all-round performance, in conjunction with the new Hughes MA-1 automatic navigation and fire-control system. Higher speed results from the introduction of a more-powerful Thiokol solid-propellent motor, and better altitude performance from an increase in wing area. The GAR-3 also has an improved semi-active radar homing system, mounted behind a pointed white plastic nose-cone which is better able to withstand the heat and abrasion that are encountered in high-speed flight.

The GAR-3 is in production at Hughes' Tucson plant and will become standard armament on future U.S.A.F. Air Defense Command all-weather interceptors, including the F-106. Nor is it the end of the line, for Hughes are already developing the GAR-9 with a nuclear warhead.

Length, 7 ft. 1 in.; diameter, 6½ in.; span of wings, approx. 2 ft. 5 in.; firing weight, approx. 150 lb.; range, over 5 miles.

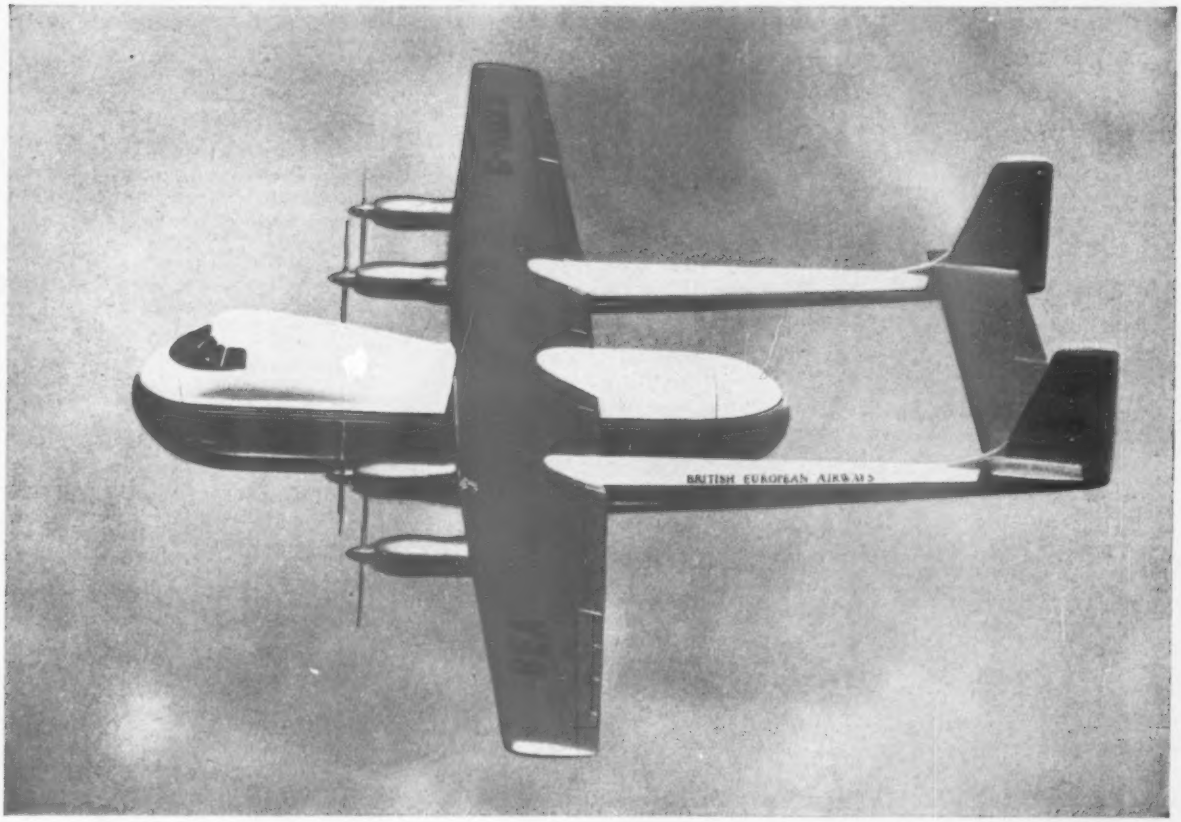
TAAM-1D

Japanese air-to-air missile. Under development

The Fuji Precision Company is developing an air-to-air missile under contract to the Japanese Defense Agency. Designated TAAM-1D, the missile has a slim tail-first configuration on the lines of the American Sidewinder. It was first tested from a ground launcher on a range near Mount Fuji in June, 1958, when it covered a distance of some 8,200 ft. at an estimated speed of Mach 1.5 at burn-out.

Length, 8 ft. 6 in.; firing weight, 333 lb.

The Philco Sidewinder in service with the U.S. Navy has an infra-red homing head; this missile can claim the distinction of being the first guided air-to-air weapon used in active service.



BRITISH ALUMINIUM

in the ARGOSY Freightercoach

The Argosy is the first true multi-purpose, pressurised, turbo-prop aircraft in the world. Designed for the economic carriage of freight, passengers or mixed traffic over medium stage routes throughout the world, the Argosy was developed specifically for operating at low cost, with ease of maintenance, reliability and real flexibility. British Aluminium, as materials suppliers to Sir W. G. Armstrong Whitworth Aircraft Ltd, are proud to be associated with this venture.

The BRITISH ALUMINIUM Co Ltd

NORFOLK HOUSE ST JAMES'S SQUARE LONDON SW1

AP-172

Keeping water out of aviation fuels and liquid hydrocarbons is a job for a FRAM Separator Filter. And not only water . . . FRAM keeps out solids too— anything down to 5 microns. Standard units are for large-scale installations handling flow-rates of 25 to 1,000 i.g.p.m. or more. FRAM trailer-mounted Separator Units can be readily moved to any location.

FRAM Separator Filters and Simmonds Control Valves are subjected to stringent tests in the Firth Cleveland Test House at Treforest. Proving their function under controlled conditions ensures that performance is always up to specification.

Full details of FRAM separator filters from

SIMMONDS AEROCESSORIES LIMITED Treforest Glamorgan A Member of the Firth Cleveland Group

CRC 9WS

Aircraft for Long-range Hypersonic Flight

DR. A. J. EGGERS, *of NASA was one of fifteen speakers at the recent symposium of the Colston Research Society on Hypersonic Flow.* *Extracts from his paper are given below. The figure numbers are those appearing in the original paper. Editorial comment on p. 447.*

Summary

MOTION and heating in long-range hypersonic flight are studied to determine how to increase the payload carrying capabilities of aircraft configurations. Particular attention is devoted to boost-glide flight which exploits the range potential of hypersonic speed. At flight speeds up to 18,000 ft./sec., corresponding to ranges up to intercontinental magnitude, over half the weight of an aircraft is supported by aerodynamic lift with the result that an increase in lift-drag ratio makes possible an increase in payload. Methods of increasing lift-drag ratio at these speeds, with particular regard to the arrangement of aircraft components, are therefore explored in some detail.

It is concluded from elementary momentum considerations that positioning the body entirely below the wing may be an especially attractive method provided wing and body shape are properly selected. Although this conclusion is contrary to the earlier notions of Sänger and others, according to both theory and experiment configurations of the flat-top type can, in fact, develop lift-drag ratios from 15% to 20% higher than those of corresponding flat-bottom or symmetrical types.

Maximum lift-drag ratios of flat-top aircraft configurations are attractively high, approaching if not exceeding 6 at Mach numbers up to 10. However, at higher Mach numbers these ratios decrease noticeably, primarily as a result of increased skin-friction effects, and the attendant aerodynamic heating begins to assume major proportions.

At flight speeds in excess of 18,000 ft./sec., corresponding to Mach numbers approaching 20 and greater, and ranges approaching semiglobal and greater, over half the weight of an aircraft is supported by centrifugal force. In this case, an increase in lift-drag ratio can be detrimental to the payload carrying capabilities of an aircraft, because it serves primarily to increase heating and hence the amount of coolant required to protect the vehicle.

The more attractive approach appears, in fact, to be to increase both lift and drag to yield relatively low lift-drag ratios and reduced heating, and to provide adequate manœuvrability in flight. It is demonstrated both theoretically and experimentally that asymmetric flat-top configurations of low fineness ratio may be well suited for these purposes, developing lift-drag ratios of the order of 1. Long-range flight under these circumstances is perhaps best characterized as being sub-satellite in type.

The general implications of these considerations are that with increasing speed and range the trend of hypersonic configurations will be first to more slender shapes with higher lift-drag ratios, and then at ranges the order of semiglobal and greater and speeds approaching satellite speed to more blunt shapes with higher lift and drag.

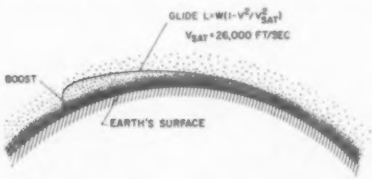


Fig. 1. Boost-glide flight.

Introductory Remarks

Long range is a natural product of flight at speeds which measure in the many thousands of feet per second. When such flight occurs in the Earth's atmosphere we term it hypersonic because the speed is large by comparison to the speed of sound. Hypersonic vehicles were initially attractive, as is so often the case, because of their military possibilities deriving primarily from reduced time of travel. Sänger appreciated these possibilities over a quarter of a century ago and, along with Bredt, made perhaps the first attempt to exploit them in designing a long-range bomber that was rocket-boosted to speed and altitude, and returned to Earth along essentially a glide trajectory.

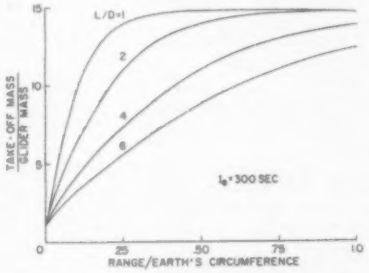


Fig. 3. Variation of mass with range.

Now, ironically though understandably enough, the simpler ballistic missile has emerged in the course of events to dominate the military scene of long-range hypersonic vehicles. Nevertheless, the fact remains that Sänger's glider concept is far more suited for manned aircraft because it permits reduced decelerations and increased manœuvrability in flight through the atmosphere.

Rocket-boosted glide-type vehicles have, of course, received considerable attention in recent times, both in regard to their motion and heating in hypersonic flight. Allen, Neice and I of the NASA compared these vehicles with ballistic vehicles and supersonic aeroplanes, and concluded that the glider may be an specially attractive long-range aircraft for either manned or unmanned applications, provided it is designed with careful consideration of aerodynamic efficiency and aerodynamic heating.

Motion and Heating of Hypersonic Gliders

The trajectory of the boost-glider is shown schematically in Fig. 1. In the boost phase of flight relatively little range is achieved while speed and altitude are increased in such a manner that at the end of boost the sum of aerodynamic lift and centrifugal force acting on the glider (due to the curvature of its flight path) just counter-balance its weight. If the entire glide trajectory is followed in accordance with this requirement, then we have Sänger's so-called equilibrium glide in which aerodynamic lift is related to weight and velocity of the vehicle by the equation shown in the figure.

We easily deduce from this equation that the majority of the weight of the vehicle is supported by aerodynamic lift at speeds less than about three-fourths satellite speed or 18,000 ft./sec., while the majority of the weight is supported by centrifugal force at higher speeds. This fact bears importantly on the motion and heating of gliders.

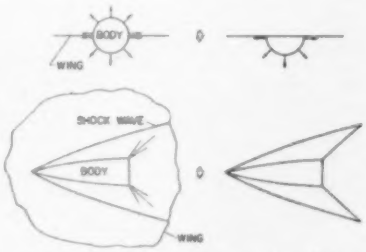


Fig. 5. Evolution of flat-top wing-body combination.

The variation of maximum speed with range of gliders developing lift-drag ratios from 1 to 6 is shown on a graph. We note, as expected, that increasing lift-drag ratio reduces the speed required for a given range, by very sizeable amounts in fact for ranges the order of one-fourth the circumference of the Earth, but by decreasing amounts for longer ranges to the point where the reductions are relatively minor at global range. This loss in effectiveness of lift-drag ratio is directly traceable to the fact that at the higher speeds required for the longer ranges most of the weight of the glider is supported by centrifugal force.

Now speed is of fundamental importance because of the predominant rôle it plays in determining the take-off mass required to place a glider in flight. If we assume that a rocket motor developing an effective specific impulse of 300 seconds is employed to boost the glider to speed and altitude, then the ratio of take-off mass to glider mass depends on range as shown in Fig. 3 for the same lift-drag ratios considered previously. Increased L/D reduces the ratio of take-off mass to glider mass; however, this reduction, like the reduction in velocity, is largest at ranges less than semiglobal and it is progressively decreased in magnitude with increasing range approaching global.

[At the end of this section, of which we have had to omit the bulk, the author makes the following observation.—ED.]

While flat-top configurations tend to retain their advantage in lifting efficiency at Mach numbers approaching 20, this advantage is small; it applies to reduced values of L/D, and it tends to be achieved with configurations which may be impracticably slender. At this point, however, we recall from our initial considerations of long-range hypersonic flight that increased lift-drag ratio may actually

subtract from overall flight efficiency at the longer ranges achieved with speeds of the order of 20 times the speed of sound and greater. We concluded, in fact, that low L/D vehicles may be more attractive for these applications and this is the possibility which we shall now explore in some detail.

Configurations Developing Low Lift-Drag Ratios

It is instructive to initiate this study by taking a rather careful look at the motion and heating of gliders near satellite speed, and we shall identify such vehicles as sub-satellites. Range and heating per unit area of sub-satellites are shown in Fig. 15. The results shown on the left of the figure are for a maximum glide speed equal to 0.9 satellite speed and the independent variable is L/D. The results shown on the right are for an L/D of 1 and the independent variable is maximum guide speed.

Considering first the range, we note that increasing L/D from 1 to 3 at 0.9 satellite speed will not even provide semi-global range, whereas increasing the speed by slightly less than 10% to near satellite value will easily provide semiglobal range, or more. Of further importance is the fact that the heating penalty associated with this speed increase is far less than that associated with the increased L/D. We have further evidence then that increased L/D is not the way to achieve ranges of the order of semiglobal and greater, but rather the key variable at these distances is speed itself.

[We have had to omit again portions of this section but the concluding observations of the author follow.—ED.]

One method of converting a half-cone body to something resembling a flyable sub-satellite is presented in Fig. 24. A small wing is located on the top of the body as shown, and the portion of the wing extending aft of the base is hinged to provide elevons for pitch and roll control. Stability about all three axes of the configuration is derived primarily from the body, while damping in roll comes mainly from the wing. Generous nose bluntness and filleting at the wing-body junction are provided to minimize heating problems in these regions. Longitudinal force and moment characteristics of a configuration like this have been measured at Mach numbers from about 3 to 13 and are given in the paper.

Experiment is compared with the predictions of Newtonian theory modified slightly to account for interference effects between the wing and the body. The agreement between theory and experiment is observed to be good on the whole, and the changes in force and moment characteristics with increasing Mach number above 3 are small. Inasmuch as the configuration is relatively blunt overall, this result is not surprising since it is, in fact, in agreement with the flow-field freeze principle of Oswatitsch.

It is also noteworthy that aerodynamic characteristics of the configuration behave in a normal fashion with small changes in angle of attack from zero. Thus, for example, lift-curve slope is positive though small, and C_{m_α} (moments are taken about the centre of volume of the configuration) is essentially constant at the negative value for $\alpha = 0$.

We have some assurance then that high-lift, high-drag configurations of the flat-top type developing lift-drag ratios of the order of 1 may be designed with suitable flying qualities at supersonic and hypersonic speeds. If the configurations are blunt to the degree of the one

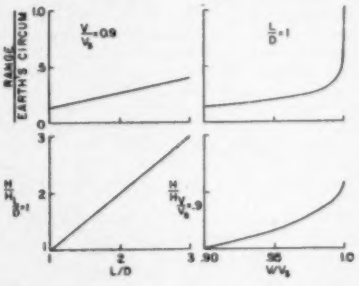


Fig. 15. Range and heating of sub-satellite.

just considered, it seems unlikely that they will be capable of a conventional landing, and parachute recovery in the terminal phase of flight will probably be required.

If a conventional landing capability is important then basically more slender configurations which can develop higher lift-drag ratios at low speeds may be necessary. It is essential, of course, to minimize hypersonic heating of such configurations insofar as possible, and this may be achieved by flying the vehicle in the manner shown in the paper. In the sub-satellite portion of flight the vehicle flies at a high angle of attack giving it "apparent" asymmetric bluntness to provide high lift and high drag.

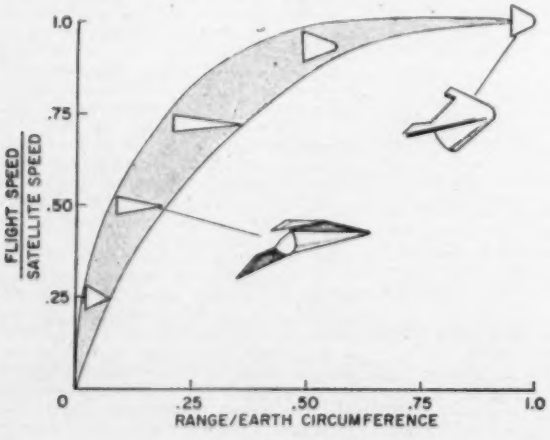


Fig. 24. Trends in hypersonic aircraft.

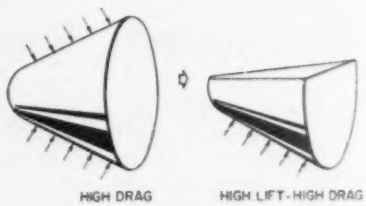


Fig. 18. Evolution of flat-top body.

As speed is decreased and the trajectory steepens the angle of attack of the vehicle is reduced to a value giving high lift-drag ratio. The sinking speed is thereby reduced to permit a conventional landing which is on water in the example illustrated in the paper.

Concluding Remarks

In conclusion it seems appropriate to summarize our findings on the trends of hypersonic aircraft configurations with increasing speed and range. These trends are shown schematically in Fig. 24. If we restrict ourselves to glider-type aircraft we can identify a speed-range corridor which is the shaded area in the figure. The boundaries of this corridor are largely determined by the requirement for reasonable payload-carrying capabilities of the vehicles.

Flight above the upper boundary tends to markedly decrease payload because lift-drag ratios are so low as to require excessively high take-off mass for a given glider mass. Flight below the lower boundary tends to markedly decrease payload at longer ranges because lift-drag ratios are so high as to cause excessive aerodynamic heating, with the result that substantial coolant must be provided to protect the vehicle. Flight below the lower boundary at shorter ranges is unattainable with known techniques for obtaining high lift-drag ratios.

The configurations that tend to fly within these boundaries are shown schematically in the shaded area. At first they increase in slenderness with increasing speed and range in order to maintain high lift-drag ratios. At ranges in excess of about one-quarter of the Earth's circumference and speeds in excess of about 0.7 satellite speed or 18,000 ft./sec. aerodynamic heating becomes the dominant factor with the result that configurations tend to become blunter again in order to minimize this heating.

We considered the problems of obtaining high lift-drag ratios at speeds up to about 18,000 ft./sec. and concluded that configurations with the body situated entirely beneath the wing may develop especially high L/D's and may be evolved into something resembling a complete aircraft configuration by drooping the wing tips. Such a configuration is slender in appearance and has essentially a flat top like the example shown in Fig. 24.

Blunter configurations for higher speed, longer range flight may also have a flat top to provide high lift to decrease heating rates along with high drag to reduce total heating. Such a configuration might appear something like the one shown on the right of Fig. 24.

If a conventional landing capability is required of sub-satellites, then they will tend to be basically more slender, with the combination of high lift and high drag being obtained with a high angle of attack to give them "apparent" asymmetric bluntness in hypersonic flight.

Correspondence

Showing the Height

ALTIMETERS are news. The old argument, now at least 25 years old, returns. Should a pilot have more instruments to gaze at or, as in the old days, pilot the aircraft using his common sense?

Mr. P. G. Procter's letter in your issue of March 27 suggesting a single-pointer dial starts the ball rolling. But what is the use of an altimeter of any shape, size or design if a pilot is going to disregard what it says for minutes on end?

Surely, if an aircraft descends at over 2,000 ft. a minute the attitude of the aircraft would indicate to the pilot that he was descending, without him looking at the altimeter. To lose 10,000 ft. by accident descending at 2,000 ft. a minute means that the pilot disregarded his altimeter for five minutes.

The awful thought occurs to me that pilots who can do such a thing might just as easily climb carelessly and cruise on Airways 10,000 ft. below their flight-planned cruising level, or "cleared" level.

Cut out most of the dials displayed in the cockpit which distract the pilot's attention (e.g., engine data) and get the boffins to design fluid-level indicators in vertical transparent tubes to give the required information. Give the co-pilot an altimeter with one needle which reads only up to 10,000 ft. A "flight-level" indicator which can be read by both pilots and an altimeter for the use of the pilot which is sensitive and reads only up to 5,000 ft. are my suggestions.

Reigate, Surrey. "BEWILDERED."

More of MACships

I NOTED in THE AEROPLANE of February 27 Mr. Hunter's story on MACships where he is at a loss whether other squadrons contributed to the effort.

Well, perhaps he will remember the Netherlands 860 Squadron under Lieut. Cdr. J. van der Tooren, R.Neth.N. (vanderT), in which Squadron I served as senior pilot.

We also were based at R.N.A.S. Maydown and manned the

MACtankers "Gadila" and "Macoma" and for one trip the "Empire Macalpine."

I believe this Squadron sank the first and only sub. ever actually encountered during the MAC session.

We did carry our parachutes and had no "Merchant Navy" on our tails, as the accompanying photograph will show you.

Wassenaar, Netherlands. F. OTTERVANGER, Capt.

Berlin's Pre-war Airport

A QUARTER of a century ago the Germans built an airport at Tempelhof with a hard-standing under cover where the biggest airliners could embark and disembark passengers in the dry, no matter what the weather. Tempelhof is as near the centre of Berlin as is Battersea Park to the centre of London.

I last saw it 10 years ago during the Airlift but maybe the runways are too short and obstructed for modern airliners. And those thousands living nearby might justly complain of the noise of certain jets!

But what makes Tempelhof outstanding is that long curved covered hard-standing which I haven't seen copied elsewhere the World over. My memory is that it could easily take the biggest aircraft of today under cover, fin and all.

So let the M.T.C.A. put up a covered hard-standing to replace the temporary hutments at L.A.P. North, for even the M.T.C.A. must now have realized that the central buildings are too small to accommodate the transcontinental traffic as well as the home and European traffic. I often wonder why officialdom takes so much longer than anyone else to get a blinding glimpse of the obvious. In a chapter on the London Airports in my "Fifty Years Fly Past" (written 10 years ago) I forecast that in a few years the Central Area would be too small.

Now that it *has* proved too small let's have a Tempelhof-type building on the North Side. I suppose it's now too late to Tempelhofize the Centre. By the time they get round to doing that, we shall have VTOL airliners operating from some more central site. But Tempelhof, even if it's too small for modern jets will come into its own again, undercover hard-standing and all, when VTOL airliners are here.

London, S.W.5. GEOFFREY DORMAN.

Groundabout

A Vanguard Named Valiant. Aviation has taken plenty from the seafarers—port, starboard, captain, first officer, steward, steering a course, ship's papers, flight deck, propeller, and other terms and practices all stem from the web-footed ones, largely via the flying-boat which belonged to both elements. And it's still going on. B.E.A., for instance, are naming their Vanguard fleet after battleships, some of the names being singularly relevant, not to say prescient. There's *Indefatigable* and *Dreadnought*, both technically reassuring, while a confident outcome of the airline rat-race is seen in *Undaunted*, *Swiftsure* and the final *Victory*. But how did *Valiant* get on the list?

*

BEA-UTIFUL. B.E.A., who have for years borne the most elegantly unenterprising aircraft markings of any airline have hit the jackpot with their splendid Vanguard/Comet scheme. Tradition discarded, a new fashion is set—glowing red wings *and no name on the white top!* May they be as courageous with the cabin interiors.

*

Call it "Viscount." A witness at the inquiry on the La Guardia Electra crash said the airliner passing low overhead sounded "eerie—something you might hear in a ghost story." Asked if he could distinguish it from the sound of a Viscount, he said: "I wouldn't know a Viscount from a discount."

*

Very Trying. A knowledgeable acquaintance tells me that the Avro triplane in the Science Museum has not got the correct engine and is inaccurate in one or two details. Whether this is so, I know not. I just want to work off the crack that they had the Wright biplane but they've got the wrong triplane.

*

Pan American't. Someone sends a Pan Am advertisement from a Buenos Aires paper, underlining the sentence: "A new magic world of speed and comfort: From New York—2½ hours to London!" Well, after all, they call it the Jet *Clipper*.

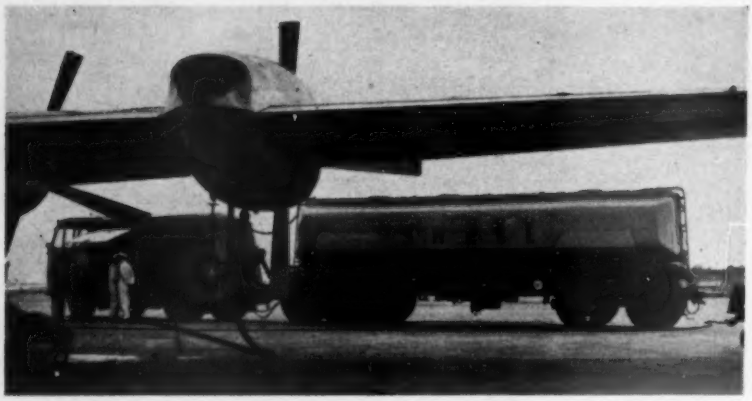
*

This correspondence must cease. And now this column's last reference to Pan Am's recent tribulations:—

"Mon Dieu, Thérèse—out there it is raining cats and pods!"

by Gordon

NOTES AND EVENTS



SUPERFUELLING.—Seen here by a Britannia turboprop airliner, Shell's Superfueller has a capacity of 7,700 gal. and a pumping speed of 550 g.p.m. It has been in operation in Germany for the past six months.

RADAR CONTROL.—B.O.A.C. has ordered a quantity of secondary radar transponders from Cossor Radar and Electronics, Ltd., for installation in its Boeing 707 fleet. Forming an airborne unit of primary ground control radar, a transponder permits more reliable and accurate observation and identification of aircraft, particularly at altitude and long range. Its use is now mandatory for high-flying civil transports in the U.S.

NEW LUBRICANTS. — The Shell Development Co. in the U.S. has produced new advanced lubricants for high-speed aircraft and guided missiles that withstand both nuclear radiation and a wide range of temperatures. The company states that results show that the new lubricants could resist heat decomposition to temperatures of over 800° F. and five times the amount of radiation possible with standard lubricants. Called polyphenyl ethers, they are made basically from benzene, a petroleum derivative and oxygen.

TRANSPORTABLE RECORDER.—A new range of Midas transportable recorders is now being introduced by Royston Instruments, Ltd., of Chertsey, Surrey. The equipment can be used for recording any variable that appears in, or can be transduced to, electrical terms, or for controlling or testing other apparatus.

NEW ADDRESS.—On April 6 Air BP changed its head office to BP House, Ropemaker Street, London, E.C.2. (Telephone, National 1200.)

TOOL STEEL.—The Tool Steel Department of the English Steel Roiling Mills Corpn., Ltd., Manchester, is producing in increasing quantities a graphitic-type tool steel. Known as M.I.C.8, it is an oil-hardened tool steel having freedom from distortion in heat treatment equal to that of conventional carbon-manganese steels. It is quite different, however, from these conventional steels in that it contains a higher carbon content, and by careful control of the analysis and metallurgical conditions of processing, a portion of the carbon is retained in the final product in the form of graphite particles. These act as a lubricant and considerably improve its machineability.

AVICA EQUIPMENT.—A new range of swivel pipe joints for general industrial applications has been designed by Avica Equipment, Ltd., of Hemel Hempstead. Initially developed in the ¼-in., ⅜-in. and ½-in. B.S.P. pipe sizes, these Mk. 3 couplings are for use at pressures up to 4,000 p.s.i.

PHOTOGRAPHY AND TV.—A full-scale display designed to speed and raise the efficiency of industry through the art of photography is to be held in the Royal Albert Hall, London, from April 20 to 24. Known as the Industrial Photographic and Television Exhibition, it will range from standard plate cameras to photo-electric controlled units, including industrial television, infra-red photography, radiography and other processes.

SARAH MARKING.—Shell Aircraft, Ltd., is using SARAH radio homing beacons produced by Ultra Electric, Ltd., in oil survey operations in the Trucial Oman Coast area. The area being worked is entirely featureless, and, due both to heat haze and dust, it is normally impossible to identify visual position markers indicating the termination of earlier operations. Homing signals have been received in S.55 helicopters equipped with SARAH receivers at 15 miles' range from an altitude of 1,500 ft.

Aviation Calendar

April 21.—R.Ae.S. all-day discussion, "The Structural Effects of Kinetic Energy," at the Inst. of Mech. Engineers, Birdcage Walk, **London,** S.W.1, at 09.45 hrs.

April 21-23.—Ninth annual convention of the International Airline Navigation Council, Hotel Manhattan, **New York City.**

April 22.—R.Ae.S. Hatfield Branch discussion evening, at The de Havilland restaurant, **Hatfield,** at 18.15 hrs.

April 22.—Women's Engineering Society London Branch lecture, "Development of the Gas-turbine Aero-engine," by A. B. McKenzie, at Hope House, 45 Great Peter St., **London,** S.W.1, at 19.00 hrs.

April 23.—R.Ae.S. Preston Branch A.G.M. and film show, at the R.A.F.A. Hall, **Preston,** at 19.30 hrs.

April 23.—R.Ae.S. Southend Branch A.G.M. and film show, at the Labour Hall, Boston Avenue, **Southend-on-Sea,** at 19.30 hrs.

April 24.—R.Ae.S./University of London lecture (sponsored by AGARD), "The Generation of Surface Waves by Shear Flows," by Prof. J. W. Miles (University of California), at Queen Mary College, Mile End Road, **London,** E.1, at 18.00 hrs.

April 24.—Fourth Tangier rally, **Morocco.**

April 24-26.—Sales Week-end organized by W. S. Shackleton, Ltd., **Kidlington Aerodrome,** Oxford.

April 27.—R.Ae.S. Guided Flight Section lecture, "Basic Principles of Radar with Particular Reference to Aircraft and Missile Applications," by F. D. Boardman, at the Institute of Civil Engineers, Great George St., **London,** S.W.1, at 18.00 hrs.

April 28-30.—Navigation Convention organized jointly by the British and French Institutes of Navigation and the Ausschuss für Funkortung, "The Place of Automation in Navigational Methods at Sea and in the Air," at **Paris.**

April 29.—R.Ae.S. Weybridge Branch A.G.M., at the Apprentice Training School, Vickers-Armstrongs (Aircraft), Ltd., at **Weybridge,** at 18.10 hrs.

April 29.—R.Ae.S. Christchurch Branch A.G.M. and film show, at the King's Arms Hotel, **Christchurch,** at 19.30 hrs.

May 2.—British Interplanetary Society lecture, "Inertial guidance and its Applications to Astronautics," by D. J. Cashmore (English Electric), at Caxton Hall, **London,** S.W.1, at 18.00 hrs.

May 2.—National Rally organized by the Duke of Bedford and the R.Ae.C., at **Woburn Abbey,** Beds.

May 5.—R.Ae.S. lecture, "The Potential Use of Aircraft for Agricultural Purposes," by R. H. Scott, in the library, 4 Hamilton Place, **London,** W.1, at 19.00 hrs.

May 5.—R.Ae.S. Luton Branch lecture, "Aircraft Carriers," by J. C. Lawrence, in the Napier senior staff canteen, **Luton Airport,** at 18.15 hrs.

FERRANTI DEVELOPMENT.—Following the success of its standard ranges of precision potentiometers, Ferranti, Ltd., of Edinburgh, has introduced a new miniature model, claimed to be the smallest wire-wound potentiometer in 3-gang form yet produced in Europe. Measuring .75-in. dia. and with a shaft dia. of .078-in., the new model, weighing only .5-oz., will be shown for the first time at this year's exhibition of the Radio and Electronic Component Manufacturers' Federation.

Company Notices

NEW COMPANIES

Chilton Aircraft Holdings, Ltd. (624,206).—Private co. Reg. March 26. Cap. £51,000 in £1 shs. (1 "A" ordinary and 50,999 ordinary). Objects: To acquire the whole of the issued sh. cap. of Chilton Electric Products, Ltd., and Chilton Aircraft Co. Ltd., for the purpose of co-ordinating and developing the activities of the said companies, etc. Subscribers (each with one sh.): Patten E. Bridge, 16 Frognal, London, N.W.3, solicitor; and Edward Wiltshire, West London Hotel, London, W.2, articled clerk. First directors: Alexander R. Ward, Cyril A. F. Fuller-Shapcott, Col. Edward J. S. Ward and John M. Freeman. Solrs.: Theodore Goddard and Co., 5 New Court, London, W.C.2.

Oxford Aviation Co., Ltd. (624,137).—Private co. Reg. March 25. Cap. £3,000 in £1 shs. Objects: To carry on the business of proprietors of the Oxford Aeroplane Club and to carry on the business of instructors in aviation and aerial navigation, etc. Directors: John K. Elliot, address not stated; Patrick N. Raison Trinafor, Broadway, Worcs; Peter L. Jewson, Stanley G. Jewson and Rex A. Smith.

New Patents

APPLICATIONS ACCEPTED

813,568.—Payen, R. N.—"Aircraft."—May 10, 1955. (May 10, 1954, and Oct. 6, 1954.)

813,692.—English Electric Co., Ltd.—"Aircraft cockpits."—Jan. 4, 1957. (Jan. 11, 1956.)

Applications open to public inspection on May 21, 1959; opposition period expires on Aug. 21, 1959.

STRAIGHT
—as a missile

The bore of a SAUNDERS Diaphragm Valve is of pipeline diameter and as straight as a missile throughout its length. For missile and rocket fuels such as H.T.P., L.O.X., and R.F.N. there are airborne and ground duty SPECIAL VALVES in the Saunders range.

SAUNDERS VALVES

A Research Panel of fluid control technicians is at the disposal of Aircraft and Weapon Engineers.

SAUNDERS VALVE COMPANY LIMITED
Aircraft Division
BLACKFRIARS STREET HEREFORD

WESTON
AIRCRAFT INSTRUMENTS

For the indication of

TEMPERATURES

PRESSURES

CONTROL SURFACE POSITIONS

TURBINE SPEEDS

ELECTRICAL POWER

Also
NAVIGATIONAL AIDS · GROUND TEST SETS
ICE WARNING INDICATOR · RELAYS, etc.

Model S149
Circular Scale
Indicator. 2" dia.
Hermetically sealed.

SANGAMO WESTON LIMITED

ENFIELD MIDDLESEX
Tel: Enfield 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield
Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 411 51
Branches: London, CHAncery 4971 · Glasgow, Central 6208
Manchester, Central 7904 · Newcastle-on-Tyne, Newcastle 26867
Leeds, Leeds 30867 · Liverpool, Central 0230 · Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 · Bristol, Bristol 21781 · Southampton, Soton 23328

SW/74

mould it in Hallprene

. . . a range of synthetic rubbers which are resistant to oil and petrol, heat, sunlight and ozone. They can be precision moulded into a wide variety of shapes and forms, and various degrees of hardness to meet "D.T.D.", "C.S.", "B.S." and "K" specifications.

Fabrics—asbestos, cotton, Nylon—coated with "Hallprene" synthetic rubbers produce sheetings and diaphragm materials of exceptional strength and stability.

"HALLPRENE" has

LOW TEMPERATURE FLEXIBILITY ***LOW COMPRESSION SET***

Write today for full details to :—

HALL & HALL LTD

OLDFIELD WORKS HAMPTON MIDDLESEX *TELEPHONE* MOLESEY 2180

P.1534

'DIAMOND H' Hermetically Sealed Miniature Relays

For Guided Missiles, High speed aircraft, Computer and other high performance applications

SERIES B R.

HERMETICALLY SEALED 4 P.D.T. RELAYS

Series BR relays are hermetically sealed 4-pole D.T. high performance components. Weighing 4 ozs. or less, they offer vibration resistance better than 2,000 c.p.s. at 20 G, operating shock resistance to 50 G and temperature range from −65° C. to +200° C.

Applications range from guided missiles and high speed aircraft to computers, fire control, radar, etc

Mounting Arrangements to suit all requirements

This is one of the wide variety of standard mounting arrangements available for " Diamond H " relays.

SERIES B S.

HERMETICALLY SEALED 4 P.D.T. RELAYS WITH SEPARATELY SEALED COIL—INORGANIC SWITCH MECHANISM

Greatest dry circuit reliability is assured in series BS relays. by virtue of the coils being separately sealed within the outer hermetically sealed case. The switch mechanism contains no organic matter, hence contact contamination is eliminated. Dry and wet circuits can be safely intermixed. Electrically and physically, series BS relays are interchangeable with series BR relays.

'DIAMOND H' SWITCHES LIMITED.

GUNNERSBURY AVENUE, CHISWICK, LONDON, W.4.

Telephone: CHISWICK 6444 (5 LINES)
Telegrams:- DIAMONHART. CHISK. LONDON

BATTERIES AND BOFFINS

In research and development work, particularly on rockets and guided weapons, Venner Silver-Zinc Accumulators have provided brilliant answers to otherwise insoluble problems. Smallest and lightest in the world, they make almost negligible demands on 'pay-load' capacity—yet their high power/weight ratio and constant voltage make them ideal power units for vital telemetering equipment.

Venner Type SZ.6
is $1\frac{3}{16}$" long, $1\frac{1}{16}$" broad and $1\frac{3}{4}$" high.
Capacity: 9 amp. minutes at 3 minute rate.

Venner Type SZ. 6/12
is $4\frac{13}{16}$" long, $1\frac{13}{16}$" broad and $2\frac{3}{8}$" high.
Capacity: 60 amp. minutes—12V. at 3 minute rate or 120 amp. minutes—6V. at 3 minute rate.

VENNER Accumulators

Write for brochure AE/SZ
VENNER ACCUMULATORS LIMITED, Kingston By-Pass, New Malden, Surrey. MALden 2442
A member of the Venner Group of Companies

CABIN COMPRESSORS · COLD AIR UNITS

VALVES · SENSING UNITS · WATER EXTRACTORS

VAPOUR CYCLE COOLING EQUIPMENT

FANS · RADAR COOLING UNITS · TURBO ALTERNATORS

PNEUMATIC ACTUATORS · STATIC COOLING UNITS

TEST CABINETS · PRESSURE TESTING TROLLEYS

AIR CONDITIONING TROLLEYS

GODFREY
SIR GEORGE GODFREY & PARTNERS LTD

SIR GEORGE GODFREY & PARTNERS LIMITED
HANWORTH, MIDDLESEX · HENLEY, OXFORDSHIRE
Telephone: FELtham 3291 Cables: Godfrepart, London
ASSOCIATED COMPANIES IN CANADA, AUSTRALIA, SOUTH AFRICA

ENGLISH ELECTRIC AVIATION LIMITED

AIRCRAFT DIVISION

Expansion of the Aircraft Division following recent Government contracts has created Vacancies for

STRUCTURAL AND AIRWORTHINESS ENGINEERS IN THE STRESS OFFICE

of our Design and Research Establishment at Warton.

The structure of a supersonic aircraft must be designed to meet stringent requirements of static loading, temperature and fatigue, and at Warton the most advanced stress analysis techniques have been developed making full use of the D.E.U.C.E. computer and our extensive research facilities. In this progressive atmosphere, engineers are encouraged to apply their technical skill to the fundamental design and analysis problems, while the computer relieves them of an increasing bulk of routine arithmetic and supplies detailed stressing data of great refinement.

Applications are invited from men between 25 and 30 years of age, who have a Degree or H.N.C. and at least three years experience in an aircraft stress office, for positions as

Structural Engineers
for design and detail stressing calculations

Airworthiness Engineers
for defining loading and environmental requirements

Stress Analysis Engineers
to extend techniques of stress analysis and computation

The Research and Development Centre of the Aircraft Division is situated in pleasant country surroundings at Warton, only a few miles from the seaside resort of Lytham-St-Annes. The positions offered are permanent and after a qualifying period successful applicants will be admitted to the Company's Pension Scheme.

Please apply to **Department C.P.S., 336/7 The Strand, London, W.C.2, quoting reference number A1796D**

CASTORS IN AIRCRAFT SERVICING

Flexello castors are being used all over the world in all climatic conditions, in the building and maintenance of aircraft. Flexello's enormous range of castors covers every field of industry and domestic life.

SPECIAL 3-4 TON FLEXELLO JACKING CASTOR

Designed and developed specially to meet requirements in certain fields of the Aircraft Industry

Our Fabricating Division designs and manufactures "specials" for extra heavy and difficult applications.

Flexello CONSTANT QUALITY **CASTORS**

For full particulars apply to Dept. A
Flexello Castors & Wheels Ltd. Slough, Bucks. Tel: Slough 24121

STEEL STAMPINGS LIMITED

Meeting every new call for Service by the Aircraft Industry

We manufacture
PRESSINGS in STAINLESS STEEL and other materials;
PRESSINGS FOR ROCKETS, WELDED RINGS, etc.

Phone: Wolverley 266
Grams: Stampings, Cookley

Cookley, Near Kidderminster

THE AEROPLANE CLASSIFIED ADVERTISEMENTS

PRESS DAY: First Post, THURSDAY

RATE: 10d. per word (minimum 12 words 10/-).

AIRCRAFT FOR SALE

W. S. SHACKLETON, LTD.,

EUROPE'S LEADING AIRCRAFT BROKERS.

TAKE PLEASURE IN LISTING SOME OF THE FOREIGN DESIGNED AIRCRAFT WHICH WILL BE AVAILABLE FOR SALE

AT THE

SHACKLETON SALES WEEK-END,
OXFORD AIRPORT, KIDLINGTON,
APRIL 24-26,
11.00 a.m. to 6.00 p.m. daily.

U.S.A.

BEECH. Super 18, Bonanza.
CESSNA. 172, 310.
LOCKHEED. 12A.
PIPER. Apache, Comanche, Tri-Pacer, Super Cub.

ITALY.

AVIAMILANO. Falco.
PIAGGIO. P.136, P.166.

FRANCE.

DRUINE. Turbulent.
JODEL. D.117.

BELGIUM.

AVIONS FAIREY. Tipsy Nipper.

CZECHOSLOVAKIA.

SUPER AERO 45.

GERMANY.

RHEIN-FLUGZEUGBAU. R.W.3.

W. S. SHACKLETON, LTD.,

175 PICCADILLY, LONDON, W.1.
Phone: Hyde Park 2448-9.
Cables, "Shackhud, London." 485-11

GRUMMAN Widgeon VP-KNV amphibian, six seats. Queen II engines, D.H. propeller, full blind-flying panel, V.H.F. and M.F., R/T excellent condition, two years' spares available, fly away, Croydon. A. J. Whittemore (Aeradio), Ltd., Croydon Airport, Surrey. zzz-682

PRIVATE owner wishes to dispose of for best offer near £1,775 a Chipmunk with only 10 hours flying, C. of A. till March, 1960, full panel, navigation, landing, cockpit lighting, 10-channel V.H.F. Desmond, care of Saxons, Ltd., Crown Wharf, Port Talbot. 486-8827

PIAGGIO EXECUTIVES.

THE 6-8-SEATER P.166, THE P.136-L AMPHIBIAN AND THE AEROBATIC P.149-D CAN BE IMPORTED ON AN OPEN GENERAL LICENCE WITHOUT DOLLAR WORRIES.

ASK YOUR DEALER, OR WRITE

AERO-ENTERPRISES (BOREHAM WOOD), LTD.,

17 DRAYTON ROAD, BOREHAM WOOD, HERTS. 485-1111

FOR sale. Privately owned Auster Alpine, late 1957, 35 hours since new. Full details and price on application. Haigh, Thaxted, Essex 294. 486-8829

PROCTOR 4 3-seater, fitted upholstery, blue, dual control, spade-type sticks, radio, full blind panel, carpets, engine new last year, 50 hours only, new tyres, finished in blue and grey, most exceptional aircraft, C. of A. until February, 1960, price £450. H.P. terms available, part exchanges car, etc. Salisbury Motor Co., 60-64 Fisherton St., Salisbury. Phone 6025. 485-8

TRAVELAIR, LTD.,

AIRCRAFT SALES AND FINANCING SPECIALISTS.

DOUGLAS DC6. On behalf of Cathay Pacific Airlines, Ltd., we are privileged to offer for sale exclusively this fine aircraft which is the long-range passenger version, to be offered with nil hours since major overhaul and modified to increase take-off weight of 95,200 lb. Alternatively can be sold in present condition—that is, due for major overhaul. Quick sale required, all offers considered.

BRISTOL 170 Mark 21 and Mark 31. We are privileged to offer for sale on behalf of the Pakistan Government forty-eight passenger-freighter aircraft, unique opportunity to acquire a number of these aircraft whose tremendous payload, extensive loading facilities, economy and flexibility of operation guarantees a good margin of profit for operators of this type. All offers will be considered and most attractive terms for "package deals."

ONE year's spares supply with each aircraft.

H.P. Terms gladly arranged, and for full details contact:—

TRAVELAIR, LTD., 115 Oxford St., London, W.1. Phone, Gerrard 3382. 485-21

TRAVELAIR LIMITED

Aircraft Sales and Financing Specialists

We are the appointed U.K. distributors of the

MOONEY MARK 20 SERIES

In the latest 1959 MOONEY MARK 20 you get advantages proved by performance to be aviation's biggest value . . . Plus the NEW STYLING to make the Mark 20 smarter and faster. Just compare it with any other four seater aircraft and see that you get more for less money in the Mark 20. Compare its roomy, luxury finish, no-noise cabin with 9 cubic feet of baggage space. Enjoy its smooth-flight comfort in all types of weather.

Some facts and figures:—

- ★ 150 H.P. Lycoming O-320 engine.
- ★ 165 M.P.H. cruise at 75% power.
- ★ Over 20 Miles per gallon fuel.
- ★ 900 Miles maximum range.
- ★ 120 lbs. baggage compartment.
- ★ Fully retractable tricycle undercarriage.
- ★ All metal fuselage.
- ★ Laminar flow wing design.
- ★ Maximum comfort for four adults.

We can offer one of these aircraft for early delivery to U.K., **duty paid**, for **£6,850** approx. All enquiries to U.K. distributors.

TRAVELAIR LIMITED
115, OXFORD STREET, LONDON, W.1
Telephone: GERrard 3382

For Narco and ARC radio equipment
Sole Distributors in Gt. Britain & Ireland

I.A.C.

62 Merrion Square, Dublin. Phone 62791

DERBY AVIATION LTD

AIRCRAFT & ENGINE OVERHAULS
SALES — SERVICE — TUITION
SCHEDULED AND CHARTER OPERATORS
DERBY AIRPORT
Telephone: ETWALL 371

Just in time for
THE SUMMER SEASON
we are able to offer

ONE AUSTER AUTOCRAT

fully overhauled in our own works, and with new 12 months' or 3 years' C. of A. as required by the purchaser.

Details from our Derby offices.

LONDON OFFICE: Tel.: Abbey 2493
78 BUCKINGHAM GATE, S.W.1

R. K. DUNDAS, LTD.

BRIEF AVAILABILITY GUIDE.

PROCTOR V, L.R. tanks, superior, £800.

ALPINE, 1957, almost new, £2,985.

PRINCE Executive, £10,500.

HERON II, 1955, little used, £29,500.

DOVE Executive, airline maintained, £14,500.

AUSTER V, zero hour engine, £1,300.

TIGER MOTH, zero hours throughout! £750.

D.C.3, Ex major airline, £21,500.

PROCTOR IV, new C. of A., radio £495.

AVRO 19, 10 seats, full C. of A., from £3,850.

JUST some of our aircraft currently available and, of course, many sleek Americans.

STOP Press! Just in!

PIPER Apache, the best yet! Only 60 hours since new, £9,450.

R. K. DUNDAS, LTD. Dundas House, 59 Saint James's St., London, S.W.1. Phone, Hyde Park 3717. Cables, "Dunduk, Piccy, London." 485-22

ROLLASONS for Tiger Moths. Croydon 5151. zzz-657

TIGER MOTH, C. of A. to April, 1960, engine 250 hours to run, superb condition, £575. J. Pothecary, Christchurch Aero Club, Christchurch 1689. 485-23

TIGER MOTH, just completed C. of A., dual controls, £550 for quick sale. Box A856, care of THE AEROPLANE. 485-x6506

HANTS AND SUSSEX AVIATION, of the Airport, Portsmouth, offer the following three completely rebuilt high-quality zero-houred aircraft for sale:—

AVRO 19 Series 2, metal wing, nil hours all round, 10 channel V.H.F. and radio compass, 8 passenger seats.

RAPIDE Mk. 4, Queen II engines with constant speed propellers, 6 passenger seats, 18-gallon long-range tanks, nil hours throughout, all new fabric, MR 80 V.H.F. and radio compass.

STANDARD 8-seat Rapide, Queen III engines, nil hours throughout, all new fabric, MR 80 V.H.F. and radio compass, X9 or X8 fixed pitch propellers to order, 9-gallon long-range tanks fitted.

FOR further details of the above, contact Hants and Sussex Aviation, or phone Portsmouth 63051. 485-8822

Aircraft Wanted

AUSTER Autocrat wanted. Lancashire Aero Club, Barton Aerodrome, Eccles 1866. 485-x6446

AUSTER AUTOCRAT; state price and full particulars. D. Bircher, High St., Hadley, Shropshire. 485-x6507

AIRCRAFT ACCESSORIES, SPARES AND COMPONENTS

COMPONENTS, spares and instruments for all aircraft and engines. A.R.B. released. Airtrade, Ltd., Croydon Airport. Phone, Croydon 0643. zzz-691

ROLLASONS are specialists in the overhaul of all Gipsy engines. Croydon 5151. zzz-659

PHILLIPS AND WHITE, LTD.

OFFER from stock a comprehensive range of new spares and components for the following engines: CHEETAH IX, X and XV de Havilland Gipsy, Major and Queen series.

INSTRUMENTS and instrument parts, navigational equipment, electrical components and aircraft spares are also available from stock.

61 QUEENS GARDENS, London, W.2. Phone, Ambassador 8651, 2764. Cables, "Gyrair, London." zzz-670

THE REGIONAL AIR TRADING CO., Croydon Airport for Rapide spares of every description. Phone, Croydon 8521. zzz-663

ROLLASONS for Tiger Moth and Gipsy engine spares. Croydon 5151. zzz-658

REPAIRCRAFT SERVICES, The Common, Cranleigh, Surrey. Cranleigh 536. Instruments and Autopilot overhaul test sales. Dakota and most other instruments from stock. zzz-701

AIRFRAME spares for Dakotas, Harvards, Piper Cub, Fairchilds Argus, Beechcraft, D-17S Mosquito, Spitfire, Firefly. Engine spares for Pratt & Whitney, Armstrong Siddeley, Lycoming, etc., accessories and instruments for all types of aircraft. A. J. WALTER, LTD., The Drive, Horley, Surrey. Phone, Horley 1420 and 4294. Cables "Cubeng, London." 485-15

HELICOPTERS

HELICOPTER SERVICES, LTD., offer their aircraft for all charter services. 96 Piccadilly, London, W.1. Gro 5495-6. zzz-692

HELICOPTERS charter, U.K. and overseas. Autair, Ltd., 75 Wigmore St., London, W.1. Welbeck 1131. 485-688

APPOINTMENTS BUREAUX

JUNIOR traffic staff urgently required, also pilots with 500-1,000 hours, experience on Vampire aircraft, for short-term engagement.

PLANAVIA International Aeronautical Appointments Bureau, 338 Kilburn High Rd., N.W.6. Mai 3142. 485-20

CLOTHING

R.A.F. Officers' uniforms for sale, new and reconditioned. Fisher's, 86-88 Wellington St., Woolwich. Phone 1055. zzz-672

SOLDERING EQUIPMENT BY LITESOLD

PRECISION SOLDERING INSTRUMENTS for the ELECTRONICS INDUSTRY

- Comprehensive Range
- Robust and Reliable
- Light weight
- Rapid heating
- Bit sizes 3/32in. to 3/8in.
- 'Permabit' or Copper Bits
- All voltage ranges 6/7v to 230/250v
- Prices from 19/6

British and Foreign Patents. Registered designs. Suppliers to H.M. and Foreign Governments. Agents throughout the world. Write for Booklet No. S.23.

Illustrated is the 25 w 3/16 in. replaceable bit model with safety shield.

Sole proprietors and manufacturers:—

LIGHT SOLDERING DEVELOPMENTS LTD.

106 George Street, Croydon, Surrey.

Telephone: CROydon 8589.
Telegrams: Litesold, Croydon.

AIRCRAFT SPRING WASHERS

To B.S. SPECIFICATION 2 SP.47.

CROSS MFG. CO. (1938) LTD. COMBE DOWN, BATH.

Southend Municipal Flying School

Commercial and Private Pilot's Licence. Instructors Rating. Night Flying every night. No entrance fee or subscription.

Austers £4 5s., Chipmunks £5 5s., dual or solo. Contract rate £3 15s.

Municipal Airport, Southend-on-Sea, Essex

Phone: Rochford 56204

SENIOR DESIGN ENGINEERS

required by

BLACKBURN ENGINES LIMITED

Applications are invited for the positions of Senior Designers with extensive knowledge of design and development engineering and with at least 5 years experience on aero and industrial gas turbines.

The work is of a varied and interesting nature and the salary is in accordance with experience and qualifications.

Attractive pension scheme, good working conditions and welfare facilities are offered together with removal expenses.

All applications will be acknowledged and treated in the strictest confidence.

Apply giving full particulars to :

The Design Office Manager, Blackburn Engines Limited, Brough, Yorkshire.

CONSULTANTS

R. W. SUTTON (CONSULTANTS), LTD., 7 Landsdown Place, Cheltenham. Phone 5811. 495-8824

R. H. STOCKEN, F.R.Ae.S., Eagle House, 109 Jermyn St., S.W.1. Whitehall 8863. zzz-696

ENGINES AND ENGINE SPARES

GIPSY MAJOR Mk. 10 and Mk. 1 engines, part-exchange offered with your time-expired engine; propellers for most types of light aircraft. Mitchell Aircraft, Ltd., The Airport, Portsmouth. Phone 717641. zzz-689

HIRE AND CHARTER

RAPIDES for hire or charter. A. J. Whittemore (Aeradio), Ltd., Croydon Airport, Surrey. zzz-683

AIRCRAFT for hire, Auster, Proctor Gemini, Tiger Moth. Vendair. Croydon 5777. 485-18

BRISTOL 170 Wayfarer for Barthull Charter, passenger or freight, fitted 48 seats. Long term preferred. Apply Shortcut Aviation, Ltd., Godstone Rd., Whyteleafe, Surrey. Phone 8211. 485-17

MACHINERY, TOOLS AND PLANT

CRANE: 6-ton Coles mobile diesel-electric crane for sale, in new condition. Burnaston Engineering Co., Ltd., Burnaston, Derbys. Phone, Etwall 451. 487-8830

NOTICES

AIR TRANSPORT ADVISORY COUNCIL.

THE AIR TRANSPORT ADVISORY COUNCIL give notice that they have received the undermentioned applications to operate scheduled air services:—

FROM DERBY AVIATION, LTD., OF DERBY AIRPORT, BURNASTON, DERBY:—

APPLICATION NO. 2510 for a U.K. Internal Service with Dakota and Marathon aircraft for the carriage of passengers, supplementary freight and mail on the route Cardiff and/or Bristol-Derby at a frequency of seven return flights weekly increasing in accordance with traffic demand for seven years from date of approval.

FROM SILVER CITY AIRWAYS, LTD., OF 62 BROMPTON ROAD, LONDON, S.W.3:—

APPLICATION NO. 2511 for a Normal Scheduled Service for the carriage of passengers, supplementary freight and mail and for a Vehicle Ferry Service for the carriage of vehicles, incidental passengers and supplementary freight, on the route Valley or Mona-Dublin with Bristol 170, Dakota and Heron aircraft at initial frequencies of four return flights daily on the Normal Scheduled Service and 20 return flights daily on the Vehicle Ferry Service, increasing later in accordance with traffic demand for seven years from the spring of 1960.

FROM TRANSAIR, LTD., OF GATWICK AIRPORT, NR. HORLEY, SURREY:—

APPLICATION NO. 98/6 for an extension for seven years from September 30, 1959, of the period of approval of the seasonal U.K. Internal Service which they are authorized to operate on the route London (Gatwick)-Guernsey and/or Jersey so as to enable them to operate the service with Viscount aircraft at a frequency of one return flight each Friday and six return flights each Saturday from June to September each year from 1960 to 1966.

These applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3 Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. 485-10

ADVERTISER, concerned with new project, anxious to contact young man (C.P.L.) resident in north. Box A851, care of THE AEROPLANE. 485-x6410

PACKING AND SHIPPING

R. AND J. PARK, LTD., 143-9 Fenchurch St., E.C.3. Phone, Mansion House 3089. Official packers and shippers to the aircraft industry. zzz-674

PHOTOGRAPHY

NEW American and British cameras, all types, also spares. G.S.A.P. gun cameras. E.W.S. Co., 69 Church Rd., Moseley, Birmingham. 487-8806

RADIO AND RADAR

SPERRY Zero reader, Type ZLI, course selectors, control panels, flight computers and indicators, three complete installations in stock. A. J. Whittemore (Aeradio), Ltd., Croydon Airport, Surrey. zzz-684

STR12D, STR9Z, STR9X and most other British and American V.H.F. R/T equipment always in stock. A.R.B.-approved design installations into any type of aircraft. A. J. Whittemore (Aeradio), Ltd., Croydon Airport, Surrey. zzz-685

NO. 4 Mark 6 radar trailer van installations for sale, complete and in working condition, ranges on P.P.I. 0-40,000, 80,000 and 120,000 yards. Would suit flying club. Can be seen working by appointment in Manchester area. Phone or write: G. Corner and Co., Ltd., Radar Department, Johnson Brook Rd., Hyde, Cheshire. Phone, Hyde 3493 (five lines). 485-14

SITUATIONS VACANT

A.F.R.Ae.S., A.R.B.Certs., A.M.I.Mech.E., etc., on "No pass, no fee" terms. Over 95% successes. For details of exams. and courses in all branches of aeronautical work, aero engines, mechanical engineering, etc., write for 148-page handbook—free. B.I.E.T. (Dept. 703), 29 Wright's Lane, London, W.8. zzz-690

FLYING instructor possessing Commercial Licence with full G.A.P.A.N. endorsement. Basic salary within range £605-£725, plus 10s. per hour flown. Superannuated post. Immediate application to, or further details from, the Manager, Municipal Air Centre and Flying School, Municipal Airport, Southend-on-Sea. 485-4

Hawker Siddeley

GUIDED WEAPONS DIVISION

A Design Office is being formed at

KINGSTON, SURREY

to carry out the design of a new Air Launched Strategic Guided Missile. This is a major Guided Weapon Project and must be developed with all possible speed. There are immediate openings for :

DESIGN DRAUGHTSMEN, STRESSMEN and WEIGHT CONTROL ENGINEERS

with Aircraft and/or Guided Weapons experience.

This is an opportunity to join a compact team in new premises with every opportunity for further advancement.

The office is located close to Kingston and Richmond Park. A Group Pension Scheme is operated.

Applications should be made to :—

Chief Draughtsman,
A. V. ROE & CO. LIMITED,
Kingston Design Office,
C/o Hawker Aircraft Ltd.,
Richmond Road, Kingston, Surrey

MARSHALL

AIRPORT WORKS CAMBRIDGE

SKILLED AERO ELECTRICIANS

FOR

INSTALLATION & TESTING

Electrical Systems in Modern Aircraft

Overtime and Production Bonus Ensure GOOD AVERAGE EARNINGS

SINGLE LODGING ACCOMMODATION AVAILABLE

SUBSISTENCE FOR MARRIED MEN

Write, Call or Telephone
CAMBRIDGE 56291 Ext. 36
EMPLOYMENT OFFICER

WIRE THREAD INSERTS

FOR NEW DESIGNS & SALVAGE

The Cross Wire Thread insert is a coil of wire having a thread form both in the bore and on the outside diameter. It screws into a tapped hole larger than the normal size, has a slight springy interference fit with its mating part and provides a hard smooth thread that will neither come out nor wear out.

CROSS MFG. CO. (1938) LTD.

COMBE DOWN, BATH Tel.: COMBE DOWN 2355/8

EAGLE AVIATION, LTD., have a vacancy for a mail and cargo officer at Blackbushe. Knowledge of import and export entries and I.A.T.A. procedures required. Apply in writing to Traffic Superintendent, Eagle Aviation, Ltd., Blackbushe Airport, Camberley, Surrey. 485-5

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, LONDON, E.C.1.

AERONAUTICAL ENGINEERING DEPARTMENT.

APPLICATIONS ARE INVITED FOR THE FOLLOWING POSTS:—

(a) Senior Lecturer—Aircraft Structures.
(b) Senior Lecturer—Aerodynamics.
(c) Lecturer (Grade B)—Aircraft Structures.

THE Department has courses for Engineering Degrees, Diplomas in Technology (Engineering), and Higher National Certificates. It provides post-graduate lectures, and research facilities for students and staff.

APPLICANTS should have an honours degree in Aeronautical Engineering, teaching experience (for the senior posts) and good industrial and/or research experience.

SALARY scales: Senior Lecturer, £1,455 to £1,677; Lecturer (Grade B), £878 to £1,295. The starting point on these scales depends on previous experience.

FURTHER particulars and application forms, which should be returned by April 27, may be obtained from the Secretary.

J. S. TAIT, Ph.D., B.Sc.(Eng.), A.R.T.C., M.I.E.E., M.I.Mech.E., Principal. 485-8825

FLIGHT Navigators.

APPLICATIONS are solicited for navigators based in Brussels with American company; must have U.S. Flight Navigator's licence and C.A.A. 2nd-class physical. Write full particulars to American International Airways, Chief Navigator, National Airport, Melsbroek, Brussels. 485-8826

JERSEY CIVIL SERVICE

AIRPORT-METEOROLOGICAL DEPARTMENT.

VACANCIES FOR METEOROLOGICAL ASSISTANTS.

Candidates should be fully trained in all branches of Meteorological Assistant work. Commencing salary at appropriate point on scale £500 to £650, in addition to which a bonus of 10% is payable on all salaries for 1959. Prospect of revision of salary scales this autumn. Write with full details of age, qualifications, experience, and names and addresses of two referees, to Greffier of the States, States' Greffe, Jersey, C.I., immediately. 485-6

SENIOR Air Pilot/Engineer required by Falkland Islands Government Aviation Dept. for one tour of three years, with prospect of pensionable employment. Commencing salary according to experience in scale, £880 rising to £1,000 a year. Free passages for officer and wife and assistance towards children's passages. Education allowance payable. Furnished quarters available at low rent. Liberal leave on full salary. Candidates, under 35 years and preferably single, must hold Engineer's A, B and C licences, current U.K. C.P.L. and R/T licence, and have had 1,000 hours as pilot in charge, preferably on single-engined aircraft. Seaplane or flying-boat experience an advantage, particularly with De Havilland Beaver seaplanes. Write to the Crown Agents, 4 Millbank, London, S.W.1, State age, name in block letters, full qualifications and experience, and quote M3C/44962/AJ. 485-9

HELICOPTER engineer, with at least A and C licences, required. Excellent prospects U.K. based. Write Brantly Helicopters, Ltd., Swansea Industrial Estate, Swansea. 486-8828

EXPERIENCED DC-4 rated pilots, first officers and ground engineers (airframe and engine) required to operate British registered DC-4 Middle East area. Apply, Group Captain Edward Mole, 3 Red Place, Green St., London, W.1. Phone, Grosvenor 4360. 485-7

SCIENCE MUSEUM: Assistant keepers. Three pensionable posts for men or women at least 21 on 1.3.59. One in department of chemistry (to be in charge of photographic collection) and two in department of aeronautics and sailing ships (one to be in charge of aeronautical collection (engines and rockets) and the other to deal with agricultural machinery and illumination collections). Qualifications: 1st or 2nd class honours degree in chemistry or engineering, or equivalent, and preferably some post-graduate experience. Knowledge of foreign languages an advantage. London salary scales (men) £1,217-£1,915 or £655-£930 according to age, qualifications and experience. Starting pay may be above minimum on the latter scale. Appointment on higher scale will not normally be before age 30 (or 28 for well qualified candidates). Promotion prospects. Write Civil Service Commission, 17 North Audley St., London, W.1, for application form, quoting S4967/59. Closing date April 29, 1959. 485-2

MINISTRY OF TRANSPORT AND CIVIL AVIATION: Air Traffic control officers. Posts for men or women at least 23 and under 35 on 1.7.59. Candidates must have had a good general education and recent aircrew experience, preferably as pilot or navigator, in civil air transport or H.M. Forces, exceptionally, extensive air traffic control experience only may be accepted, men's starting salary (London) from £715 to £1,025, maximum £1,390, promotion prospects. Write Civil Service Commission, Burlington Gardens, London, W.1, for application form, quoting 4904/59. 485-1

RADIO OPERATORS. Air Ministry have vacancies for temporary radio operators (male), good prospects of permanent, pensionable appointments and promotion, initial appointments in U.K., but subsequent tour of duty in Far East likely. Trainees £422 10s. to £605, qualified operators £507 10s. to £975. (These rates are subject to a small deduction at provincial stations and a small increase in London and overseas.) Special allowances payable for overseas service. Apply Air Ministry, C.E.4m, Cornwall House, Stamford St., S.E.1. 485-3

Hawker Siddeley GUIDED WEAPONS DIVISION

A. V. ROE & CO. LIMITED

a member of the above Division have vacancies for

SENIOR ENGINEERS

in establishments at

WOODFORD (CHESHIRE), CHERTSEY and KINGSTON-UPON-THAMES

Vacancies at WOODFORD, CHERTSEY and KINGSTON

PHYSICIST To take charge of new group engaged on analysis of Radar navigational Systems and matching of Radar with other Navigational sub-systems.

ELECTRONIC SYSTEMS ENGINEERS For development of control and data handling systems.

MATHEMATICIANS For system analysis, logical design, flight dynamics and trajectory investigations.

Vacancies at WOODFORD and KINGSTON

STRUCTURAL DESIGN ENGINEERS For airframe design of advanced missiles.

STRUCTURAL ANALYSIS ENGINEERS For work on analysis of advanced missile structures.

AERO-THERMODYNAMICISTS For initial design of new missiles projects, analysis of wind tunnel and flight data.

Applications should be sent to :—

CHIEF ENGINEER, WEAPONS RESEARCH DIVISION, WOODFORD, CHESHIRE, quoting reference No. WRD/RHF/R.62/A

GUARANTEED R.L.A.

LAMINATED ALUMINIUM

USED ON MOST IMPORTANT AIRCRAFT

A.I.D. & A.R.B.

B. ATTEWELL & SONS LTD.

IVER BUCKINGHAMSHIRE

NEW BALL & ROLLER BEARINGS

Over 5,000,000 in stock in more than 5,000 types

BRITAIN'S LARGEST STOCKS

WRITE FOR STOCK LISTS

CLAUDE RYE BEARINGS

895-921, FULHAM RD., LONDON, S.W.6

Phone: RENOWN 6174 (EXT. 24) TELEX 23453

WYNSTRUMENTS LTD

AIRCRAFT INSTRUMENT OVERHAUL

A.R.B. APPROVED

STAVERTON AERODROME

GLOUCESTER Telephone: CHURCHDOWN 3264

THE BRITISH AIRLINE PILOTS ASSOCIATION

95, Mount Street, W.1 Tel.: GROsvenor 6261

Membership open to all Commercial and Service Pilots. For full details as to Objects and particulars of Membership, please write to General Secretary.

HUNTING AIRCRAFT LIMITED

require

SENIOR DESIGN DRAUGHTSMEN

for structures, mechanical design and engine installations. H.N.C. or equivalent qualifications desirable, plus several years experience in the aircraft industry.

There is an extensive programme on all aspects of design work.

Vacancies are at LUTON only.

Holiday arrangements honoured for the current year.

Contributory Pension and Life Assurance Scheme.

Applications, giving full details of qualifications, experience, age and salary desired, and quoting ref. H.A.L./76/7, should be addressed to:—

The Personnel Manager,

HUNTING AIRCRAFT LIMITED,

The Airport, LUTON, Beds.

EXPERIENCED working warehouse foreman required for aluminium stockists. Applicants must be fully conversant with all aspects of this trade and have knowledge of A.I.D. procedure. Successful applicants will be responsible for goods inwards and outwards and must be able to control staff. Good salary, 5-day week. Box A854, care of "THE AEROPLANE." 485-12

TECHNICAL sales manager required by London electronic company. Must be good organizer, have sound telecommunications background and good contacts in the aircraft and electronic industry as well as Government Purchasing Departments. Apply, Box A855, care of THE AEROPLANE. 485-13

A-LICENCE radio engineer required; good salary. Apply, Chief Engineer, Morton Engineering Services, Ltd., Croydon Airport, Surrey. 485-12

REQUIRED by aircraft company in south of England, detail engine inspector, either licensed or inspection approved. Write, Box A832, care of THE AEROPLANE. 485-8823

COMMERCIAL pilot wanted for summer season joy-riding (Austers). J. Crampton, Oxnead, Norwich. 485-x6508

SITUATIONS WANTED

CLUB and school flying instructor seeks post. Wide experience Service and Club elementary instruction. C.L., R/T, full rating, approved for A.T.C. Box A852, care of THE AEROPLANE. 485-x6447

PRIVATE pilot studying for commercial, but out of cash, seeks flying hours, anything considered. Write, Box A855, care of THE AEROPLANE. 485-x6509

MARSHALL

AIRPORT WORKS CAMBRIDGE

SKILLED AIRFRAME FITTERS

Required for Interesting Work on

CIVIL AIR LINERS

Overtime and Production Bonus Ensure
GOOD AVERAGE EARNINGS

SINGLE LODGING ACCOMMODATION AVAILABLE

Write, Call or Telephone
CAMBRIDGE 56291 Ext. 36
EMPLOYMENT OFFICER

TUITION

EXETER AIRPORT, LTD. Courses for Commercial Pilot's Licence, from £625; Private Pilot's Licence, from £101 5s. Contract rate solo flying, Austers and Tigers, £2 7s. 6d. per hr.; normal dual/solo rates, £3 7s. 6d. per hr.; twin conversions, £6 12s. per hr.; Chipmunk, £5 5s. per hr.; Messenger, £4 18s. 6d. per hr. Limited accommodation, £5 15s. 6d. per week. Exeter Airport, Exeter. Phone 67433. zzz-680

AIRWAYS AERO ASSOCIATIONS, LTD., Croydon Airport. M.T.C.A.-approved P.P.L., C.P.L. I/R courses. Fully equipped Chipmunk, Auster, Proctor and twin-engined aircraft. Link £1 per hour. Specialist instruction. Competitive and contract rates. Phone, Croydon 9308. zzz-699

LONDON SCHOOL OF AIR NAVIGATION. MINISTRY Approved for Commercial and Instrument Rating. Subjects for all professional licences and ratings embracing academic, technical, simulated and flying; home-study excellent alternative; individual coaching; refresher courses; officially appointed by H.M. Services for Correspondence Scheme. Refer Education Officer or direct 33 Ovington Square, Knightsbridge, London, S.W.3. Kensington 8221. zzz-697

CIVIL pilot-navigator licences.

CAVIGATION, LTD., provide full-time or postal tuition or a combination of either of these methods to suit individual requirements for the above licences. Classroom instruction can be provided for A.R.B. General, certain specific types and performance schedule examination. Link Training Dept., at Monarch 1364.

FOR full details apply to the Principal.

CAVIGATION, LTD.,
30 CENTRAL CHAMBERS,
EALING BROADWAY,
LONDON, W.5.
Phone, Ealing 8949. zzz-669

LEARN to fly, £32; instructor's licences and instrument flying for £3 15s. per hour; night flying, £4 15s. per hour. Residence 6 gns. weekly. Approved M.T.C.A. Private Pilot's Licence Course. Specialized course for Commercial Pilot's Licence. Wiltshire School of Flying, Ltd., Thruxton Aerodrome (Andover Junction 1 hr. 15 min. from Waterloo), Hants. zzz-700

AIRWORK SCHOOL OF AVIATION, PERTH.

M.T.C.A.-APPROVED courses for private and commercial licences and instrument rating; residential and recreational facilities. Prospectus from Airwork Services, Ltd., 35 Piccadilly, London, W.1, or Perth Aerodrome, Scotland. 485-16

YOUR commercial pilot's course for £625. Apply to The Manager, Plymouth Aero Club, Plymouth Airport. Phone 72752. 485-676

MORLEY AVIATION, LTD. (Herts and Essex Aero Club, 1958). Aerodrome, Stapleford. M.C.A.-approved private pilot's licence course, Auster, Gemini and Tiger aircraft; trial lesson 35s.; 15 miles centre of London. Central Line Underground to Theydon Bois, bus 250 to club; open every day. Phone, Stapleford 257. 485-695

CAMBRIDGE AERO CLUB. M.T.C.A.-approved private pilot's licence course, 30 hours, £3 10s. per hour; D.4 Link Trainer for radio compass and I.L.S. procedures to instrument rating standard, £1 per hour; instructor's course, £3 10s. per hour; night flying, £4 10s. per hour; Auster J.1.N., £3 15s. per hour, dual and solo. No fees or subscriptions. Club operates on all days, including week-ends. The Aerodrome, Newmarket Rd., Cambridge. Phone 56291. zzz-703

TWIN-ENGINE conversions for your instrument rating or for private pilots. Generous deferred-payment facilities. Derby Aviation, Ltd., Elstree Aerodrome, Herts. Phone, Elstree 3070. 487-8831

CLUB NOTICES, ETC.

SURREY FLYING CLUB. Surrey and Kent Flying Club, Biggin Hill. Tiger, Hornet and Leopard Moths, Chipmunk and Prentice. Green Line 705 direct in one hour from London. Biggin Hill 2255. 485-694

BOOKS AND PUBLICATIONS

WORLD'S largest stock of old aviation books (over 15,000). Catalogue free. Top price paid for James, any year, World War I and other aviation books. Stuart, Fairlight Hall, Hastings. zzz-681

R.Ae.S. journals (unbound), 1947 to date, good condition, for sale, £25 o.n.o. Box A857, care of THE AEROPLANE. 486-x6495

MODERN AIRCRAFT DESIGN, by J. L. Naylor, provides technicians in allied industries with an account of the wide background knowledge behind the design of modern aircraft. Illustrated 128 pages, 9s. 6d. net from booksellers, or 10s. 2d. by post from the publishers, Temple Press Limited, Bowling Green Lane, London, E.C.1. zzz

OVERSEAS AVIATION

(C.I.) LTD.

Have Available For
World-Wide Charter

65 Seater Argonaut A/C

Payload 6,000 Kilos
Fully Pressurised

Also 36 Seater Vikings

FOR DETAILS PLEASE APPLY
U.K. SALES OFFICE:
PANTON HOUSE, 25, HAYMARKET, LONDON, S.W.1.
Tel: Trafalgar 3901/2 Telex: 21168 (Overseas Ldn.)

A.I.D. APPROVED
Rubbaglex
(Regd.) Patent No. 519567

Rubbaglex Sheeting is processed on 100% pure glass cloth, has very high tensile strength, is rot proof and combines flexibility and resiliency with non-stretching properties.

Impervious to Aromatic Hydro Carbons. Highly recommended for Gaskets, Washers, Jointings, Diaphragms, Sleevings, also Floating Roof Tank Seals, etc.

RUBBAGLAS
LTD.
66 VICTORIA ST.
LONDON S.W.1
VICTORIA 6501

THE ENGLISH ELECTRIC CO. LTD.
(Guided Weapons Division)
STEVENAGE · HERTS.
has vacancies for

SENIOR STRESS ENGINEERS

possessing at least three years experience of the aircraft or guided weapons industry.

Applicants should have at least H.N.C. qualifications and a degree in engineering would be preferred. The work will involve stress analysis to ensure light and efficient structures.

SENIOR WEIGHT CONTROL ENGINEERS

of minimum O.N.C. standard are required to join a small office dealing with all aspects of weight control and prediction. Applicants should possess a sound knowledge of the aircraft industry including some years experience in the field of weight control.

Housing assistance may be made available in certain cases after an initial waiting period.

Please write in first instance to Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference A1396D.

Precision Sheet Metal Workers and Light Engineers to the Aircraft Industry

with the following : Fabricated Parts and Assemblies. Manufacturers of Conduit Assemblies for the Viscount Electrical Harness, Fairings, Bulkheads, Air Intakes, Cooling Ducts, Exhaust Panels, Plug Screens, Fuel Oil or Drain Tanks, Plenum Panels, Brackets, Clips and other components in Ferrous and Non-Ferrous Metals. Tools, Jigs and Machined Parts for the Assemblies can be produced in our own Workshops. Let us quote for your requirements.

Fully approved by A.I.D. & A.R.B. *Established 1891*

C. W. FLETCHER & SONS, LTD.
STERLING WORKS, ARUNDEL STREET,
SHEFFIELD, 1 *Phones : Sheffield 28040 & 28049*
Grams : Assayed Sheffield 1

Printed in England and Published Weekly by the Proprietors, TEMPLE PRESS LIMITED, BOWLING GREEN LANE, LONDON, E.C.1.
Registered at the G.P.O. as a Newspaper. Entered as second-class matter at the Post Office at New York, N.Y., under the Act of March 3, 1879 (Sect. 538 P. L. & R.).

AGENTS ABROAD—EUROPE—Messageries Dawson (S.A.), Paris; Messageries Hachette, et Cie, Paris; W. H. Smith & Son, Paris and Brussels. CANADA—Wm. Dawson Subscription Service Ltd., Toronto; Gordon & Gotch Ltd., Toronto. U.S.A.—Eastern News Co., 306 West 11th Street, New York, 14, N.Y. AFRICA—Central News Agency, Ltd., Cape Town; W. Dawson & Son (S.A.), Cape Town. ASIA—W. Thacker & Co., Ltd., P.O. 190 Bombay. AUSTRALIA and NEW ZEALAND—Gordon & Gotch (A'sia), Ltd.

The Armstrong-Whitworth 'ARGOSY'

ALL-BRITISH

Lockheed

HYDRAULIC AIRCRAFT EQUIPMENT

LOCKHEED PRECISION PRODUCTS LIMITED

LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

Bloodhounds ready for launching during acceptance trials at Woomera

CROWN COPYRIGHT RESERVED

Effective Defence

In full operational service with the RAF as a mainstay of Britain's air defence . . .

Adopted by Sweden after exhaustive consideration of surface-to-air guided missile systems available throughout the world . . .

Proved in many hundreds of test firings . . .

Bristol/Ferranti Bloodhound forms the world's most effective defence system now and for many years to come

Security forbids publication of full details, but the following facts about Bloodhound can now be given:—

Power. The Bloodhound is powered by two Bristol Siddeley ramjets—the jet engine with no moving parts. Ramjets ensure power and range flexibility, burn kerosene, are simple and safe to handle.

Homing System. Semi-active: i.e., ground crew directs radar beam on to approaching target which is reflected to a receiver in Bloodhound missile.

This ensures highest accuracy—regardless of range. Missiles may be fired singly or in salvoes using only one radar.

Airframe. Employs unique and advanced monoplane moving wing configuration—two advantages: quicker and more precise response, as well as greater accuracy of interception—superior at high altitudes; this configuration was selected at initial design stage to embody maximum development potential.

BRISTOL/FERRANTI

Bloodhound

GUIDED WEAPON SYSTEM

Weapon design and construction by Bristol. Guidance and control by Ferranti. System sales organisation by Bristol Aircraft Limited